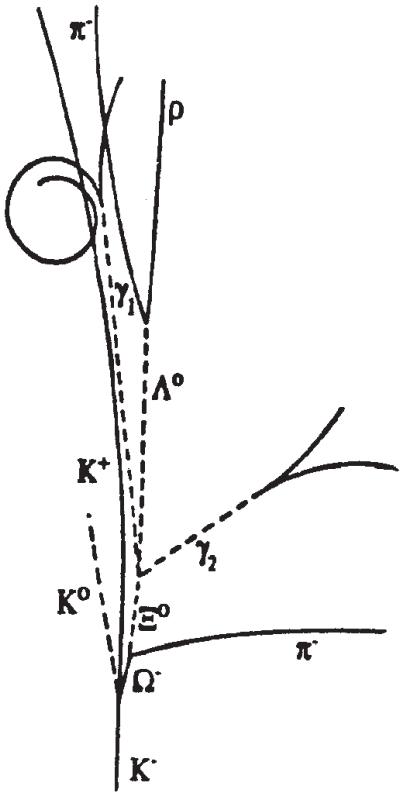
VOLUME 41, NUMBER 4, DECEMBER 2018

HADRONIC JOURNAL

HADRONIC JOURNAL Volume 41, Number 4, December 2018

Founded in 1978 by Prof. R. M. Santilli at Harvard University. Some of the past Editors include Professors S. L. Adler, A. 0. Barut, L. C. Biedenharn, N. N. Bogoliubov, M. Froissart, J.Lohmus, S. Okubo, Nobel Laureate Ilya Prigogine, M. L. Tomber, J. P.Vigier, J. Wess, Nobel Laureate Chen Ning Yang.



EDITORIAL BOARD

A.O.ANIMALU
A. K. ARINGAZIN
A. A. BHALEKAR
S. J. DHOBLE
J. DUNNING-DAVIES
T. L. GILL
L. P. HORWITZ
S. L. KALLA
S. I. KRUGLOV
M. NISHIOKA
R. F. O'CONNELL
Z. OZIEWICZ
E. RECAMI
M. SALEEM
B. G. SIDHARTH
S. SILVESTROV
H. M. SRIVASTAVA
E. TRELL
R.I. TSONCHEV
QI-REN ZHANG
C.A.WOLF
YI-ZHONG ZHUO

Founder and
Editor In Chief
R. M. SANTILLI

HADRONIC JOURNAL

VOLUME 41, NUMBER 4, DECEMBER 2018

ALTERNATE WORLD VIEW, 273
Tepper L. Gill
EECE Howard University, Washington, DC 20059
COMPUTATIONAL ATOMIC PHYSICS FOR THE FUTURE: MODULAR REALIZATION OF ATOMIC CONSTITUTION AND PERIODIC SYSTEM, 305
Erik Trell
Faculty of Health Sciences, Linköping University
581 83 Linköping, Sweden
MASS PREDICTIONS AND LIFETIME FORMULAS OF HEAVY FLAVOR HADRONS, AND SIMPLIFY OF SUPERSYMMETRY, 335
Yi-Fang Chang
Department of Physics, Yunnan University
Kunming, 650091, China
ON SEPARATION OF EXCHANGE TERMS FOR FOUR-POTENTIAL ACOUSTIC SH-WAVE CASE WITH DEPENDENCE ON GRAVITATIONAL PARAMETERS, 349
Aleksey Anatolievich Zakharenko
International Institute of Zakharenko Waves (IIZWs)
660014, ul. Chaikovskogo, 20-304, Krasnoyarsk, Russia
THERMODYNAMICS OF THE RELATIVISTIC GIANT ATOM, 371
Emad Eldieb
Cairo, Egypt

INDEX VOL 41, 2018.....385

HADRONIC JOURNAL 41, 273 - 303 (2018)
DOI 10.29083/HJ.41.04.2018

ALTERNATE WORLD VIEW

Tepper L. Gill
EECE Howard University
Washington, DC 20059
tgill@howard.edu

Received November 30, 2018

Abstract

In this investigation, we study the role for time in the representation of physical reality. Our investigation of Minkowski's postulate for time leads us to conclude that, it works well for one particle, but fails completely for two or more and has no physical justification. We then derive a new identity which shows that the correct relationship between the proper time and observer time is a contact (or tangency) transformation on configuration space, which leaves phase space invariant. This paper is devoted to relativistic mechanics. Our basic conclusions are: there always exist two unique sets of variables for any inertial observer to study a given system of particles, one with unique simultaneity and the speed of light relative, and one with a unique speed of light and time relative. In addition, there always exists two mathematically equivalent, but not physically equivalent representations for the equations of motion so the choice of variables is a convention (see Poincaré [PO1]). At the cosmic level, we show explicitly that the first two postulates of Einstein are consistent with a universal reference frame (as suggested by Peebles [PE]) and a universal clock as suggested by Newton. Using isoduaility, we suggest an improved version of the big bang model, which only requires nonconservation of energy (see Santilli [SA]). If the ratio of the total energy to the total mass energy of the universe is constant, then Newtonian time exists with zero set at the big bang. A major implication of this paper is that data from observation of distant objects does not have a unique physical interpretation.

Copyright © 2018 by Hadronic Press, Inc., Palm Harbor, FL 34684, USA

Introduction

We are now in the early part of the twenty first century. All the problems facing attempts to use the first two postulates of Einstein to extend Newtonian mechanics, classical electrodynamics and quantum theory are still with us. The replacement of particles by fields has allowed us to obtain results that are in very good agreement with experiment. However, the methods developed have led to a new set of problems, which have defied a rational solution for almost four generations.

0.1 Motivation and Background

Problems associated with the radiation of accelerated charged classical point particles are well-known. In the hope of bypassing the classical problems at the quantum level, point particles were replaced by quantum fields. However, in addition to the self-energy divergency known in the classical theory, a number of other divergent expressions appeared. Furthermore, initial attempts to use the straightforward and physically intuitive time-dependent perturbation expansion to compute physical observables were discouraging, because early subtraction methods seemed to depend on both the gauge and the Lorentz frame. Although the equations of QED were both Lorentz and gauge covariant, it was believed that they had no solutions expandable in powers of the charge. These problems were finally solved by Feynman, Schwinger and Tomonaga. However, there were no known mathematical methods which allowed for the systematic subtraction of infinite quantities at that time, so that their solution was considered temporary by all concerned.

Starting in 1950, a large body of foundational research (called axiomatic quantum field theory) was begun by some of the best physicists and mathematicians in the world, with the single-minded focus on addressing and solving this problem. Their primary goal was to provide the sound mathematical underpinnings required to justify the renormalization program.

The year 1982 marked a fundamental turning point for this enterprise. Sokal was the first to notice some difficulties with the constructive approach to quantum field theory (the concrete version of axiomatic quantum field

theory) and conjectured that this approach may not work as expected in four space-time dimensions (see [SO]). His conjecture was later verified by Aizenman and Graham [AG] at Princeton and Fröhlich [FO] at ETS, Zurich. These results were initially ignored and/or went unnoticed in the larger physics community proper. However, work on the foundations of relativistic quantum theory, began to slowly fade and the next generation placed their hopes on string theory as the best way forward. By then, renormalization had become considered a natural part of the physical landscape.

In 1986, a less well-known response to the work of Aizenman, Graham, and Fröhlich was initiated by the present author and his co-workers. We followed suggestions of Dirac, Dyson and Feynman by first starting with the "design" of a rigorous mathematical theory for Feynman's time-ordered operator calculus, where time is accorded its natural role as the director of physical processes (see [GZ1]).

In the Feynman world-view the universe is a three-dimensional motion picture in which more and more of the future appears as time evolves. In this view, time is a physically defined variable with properties distinct from those of the three spacial variables. This view is inconsistent with the Minkowski world-view, in which time is an additional coordinate for a space-time geometric representation of physical reality.

Additional motivation was to prove the last remaining conjectures of Dyson concerning quantum electrodynamics. Dyson made four well-known conjectures. The first was verified by A. Salam [AS], while the second was verified by S. Weinberg [WS]. Our theory allowed us prove:

(3) The renormalized perturbation series of quantum electrodynamics is asymptotic.

(4) The ultraviolet divergence of quantum electrodynamics is caused by a violation of the time-energy uncertainty relations (at each point in time).

Briefly, the theory is constructive in that operators acting at different times actually commute (in the mathematical sense). This led to a general perturbation expansion for all theories generated by unitary evolutions. It also led to a physically motivated explicit sum over paths formulation (Feynman diagrams) as suggested by Feynman and provided the first mathematical justification for Feynman's path integral formulation of quantum me-

chanics (see [GZ1] and [GZ2]). This work and our success with the Dyson conjectures led us to take a closer look at the physical foundations for time as an additional geometric coordinate.

0.2 History

The introduction of the special theory of relativity in 1905 caused a revolution in physics. At that time, it was unthinkable that Maxwell's theory had any serious flaws. Lorentz [L1, L2] had recently shown that all of the macroscopic phenomena of electrodynamics and optics could be accounted for based on an analysis of the microscopic behavior of electrons and ions.

Independent of Lorentz and Poincaré, Einstein took a deeper look at the problem. He derived the Lorentz transformations from kinematical arguments, as opposed to the symmetry properties of Maxwell's equations. As Brown points out [BR], Einstein took this approach because he was not sure that Maxwell's theory would survive the existence of photons. Einstein believed that the Lorentz transformations were fundamental and would survive any failures in Maxwell's theory. (At that time, Maxwell's theory was still not accepted by all, see [GZL] and references therein.)

Einstein [E1] observed that the constant c appears in Maxwell's equations for all inertial observers. At that time experimental information about the speed of light was meager, being restricted to macroscopic and astronomical studies. Einstein was the first to realized that a formal postulate on the velocity of light was necessary. His proposal was that all physical theories should satisfy the (now well-known) postulates of special relativity:

(1) The physical laws of nature and the results of all experiments are independent of the particular inertial frame of the observer (in which the experiment is performed).

(2) The speed of light in empty space is constant and is independent of the motion of the source or receiver.

Like those before him, Einstein realized that the concept of absolute space was neither knowable nor necessary. The first postulate abandons this idea.

Einstein's second postulate forces the abandonment of the idea of absolute time. Einstein formulated his theory in the usual three-dimensional notation, making the natural distinction between space and time.

Poincaré was singular among first class physicists, who were equally well trained and accomplished in engineering, mathematics, physics and the philosophy of science. (E. T. Bell called Poincaré "The Last Universalist", because he excelled in all these fields as they existed in his lifetime [ETB].) Poincaré discovered an error in Lorentz's analysis, realized that after correction the transformations form a group, which he named for Lorentz [PO2]. As early as 1906, Poincaré recognize that the Lorentz group could be treated as a rotation in four-dimensional space if time is treated as an imaginary coordinate and introduced the metric (proper-time) now attributed to Minkowski (see [PO3]). However, his deep understanding of the difference between mathematics and physics helped him to resist the temptation to use a "physically unjustified" mathematical observation as a (necessary) tool for the representation of physical reality. This leap was later made (without physical justification and much philosophical fanfare) by Minkowski, a well-known number theorist with few accomplishments in physics and a strong belief in Hilbert's program [MI] to geometrize physics. (To be fair, it was not uncommon for pure mathematicians to have a strong interest in and/or be well-versed in the important areas of theoretical and mathematical physics of the day.) A complete discussion of Minkowski's motivation, his prior knowledge of Poincaré's work and his background in physics can be found in Walters [WA]. *Thus, we make explicit Minkowski's unacknowledged postulate for the special theory of relativity.*

(3) The correct implementation of the first two postulates requires that time be treated as a fourth coordinate, and the relationship between components so constrained to satisfy the natural invariance induced by the Lorentz group of electrodynamics (Minkowski space).

It is very important to realize that after over one hundred and ten years with a number of fundamental problems in the foundations of mechanics, electrodynamics and relativistic quantum mechanics, Minkowski's postulate has never been recognized and investigated as a postulate requiring phys-

ical justification. We now have over two generations of young researchers in physics who believe that Minkowski's postulate completely encapsulates Einstein's special theory. They are unaware that the Minkowski four-vector formulation of mechanics has no physical justification, does not fully include Newtonian mechanics and is only justified by its mathematical convenience. Thus, the Hilbert-Minkowski view has completely dominated the evolution of physical thought and is directly responsible for the current state of confusion in relativistic quantum theory, quantum gravity and the corresponding lack of progress in nuclear and particle physics.

0.3 Newtonian Mechanics

The four-geometry postulate quickly became popular and was embraced by many; but other important physical thinkers, including Einstein, Lorentz, Poincaré, and Ritz, regarded it as a mathematical abstraction lacking physical content and maintained that space and time have distinct physical properties. In fact, Einstein was the first to openly oppose the Minkowski postulate. In 1908, Einstein and Laub wrote two papers that introduced a different approach to electromagnetic theory, which was simpler and did not depend on the spacetime formalism (see [EL1], [EL2]). They argued that the spacetime formalism was too complicated and did not add any new physics.

Sommerfeld later simplified Minkowski's complicated formulation, making it easy for physicists to understand. The community fell in love with the new (abstract) tensor methods and his formulation became the preferred approach within a few years. The theory also became attractive to the mathematics community, which made it even more popular. In the excitement, no one seem to notice that the theory did not work for more then one particle and thus was far from a complete extension of Newton's theory. By the time problems in attempts to merge the special theory of relativity with quantum theory forced researchers to take a deeper look at the foundations of classical electrodynamics, the Minkowski postulate had already become sacred. When Einstein considered the extension of the special to the general theory, the only approach of interest was a geometric extension of Minkowski's postulate (see Pais [PA] and [EG]).

Once it was accepted that the proper Newtonian theory should be invariant under the Lorentz group, work on this problem was actually ignored until after World War Two when it was realized that quantum theory did not solve the problems left open by the classical theory. A canonical center of mass is fundamental for the extension of the special theory to include a many-particle Newtonian or a many-particle quantum theory. The first study of the center of mass problem was conducted by Pryce [PY]. This led to the implication that the canonical center-of-mass cannot be the three-vector part of a four-vector.

His work will be discussed in more detail later. For an easy to understand related problem, consider two inertial observers O and O'. Without loss, assume both clocks begin when their origins coincide and O' is moving with uniform velocity $\mathbf{v}$ as seen by O. Let two particles, each the source of an electromagnetic field, move with velocities $\mathbf{w}_i\,(i=1,2)$, as seen by O, and $\mathbf{w}_i'\,(i=1,2)$, as seen by O', so that:

$$\begin{aligned}&\mathbf{x}_i' = \mathbf{x}_i - \gamma(\mathbf{v})\mathbf{v}t + (\gamma(\mathbf{v})-1)(\mathbf{x}_i\cdot\mathbf{v}/\left\|\mathbf{v}\right\|^2)\mathbf{v}\\ &\text{and}\\ &\mathbf{x}_i = \mathbf{x}_i' + \gamma(\mathbf{v})\mathbf{v}t' + (\gamma(\mathbf{v})-1)\left(\mathbf{x}_i'\cdot\mathbf{v}/\left\|\mathbf{v}\right\|^2\right)\mathbf{v},\end{aligned} \tag{0.1}$$

with $\gamma(\mathbf{v}) = 1/\left[1-(\mathbf{v}/c)^2\right]^{1/2}$ represent the spacial Lorentz transformations between the corresponding observers. Thus, there is clearly no problem in requiring that the positions transform as expected. However, when we try to transform the clocks, we see the problem at once since we must have, for example,

$$t' = \gamma(\mathbf{v})\left(t-\mathbf{x}_1\cdot\mathbf{v}/c^2\right) \quad \text{and} \quad t' = \gamma(\mathbf{v})\left(t-\mathbf{x}_2\cdot\mathbf{v}/c^2\right). \tag{0.2}$$

This is clearly impossible unless $\mathbf{x}_1\cdot\mathbf{v} = \mathbf{x}_2\cdot\mathbf{v}$. Thus we cannot use the observer clock to share information (with other observers) about two or more particles, so that the first postulate cannot be verified. The natural solution is to attach separate clocks to the particles. However, this leads to a number of other problems, related to the investigation of Pryce, as will be discussed in the next section.

In classical electrodynamics, Dirac partially by-passed many of the problems by replacing particles with fields (see [D]). However, this approach led

to the first example of a divergent theory (infinite self-energy). This divergency was the motivation for the Wheeler-Feynman approach to classical electrodynamics (see [WF]). Their theory solved the divergency problem, but could not be used as the foundations for quantum theory.

Following Pryce, Bakamjian and Thomas [BT] showed that they could construct a global interacting quantizable many-particle theory that satisfied the first two postulates of Einstein (but not Minkowski's postulate). They conjectured that inclusion of Minkowski's postulate would make their theory only compatible with free particles. In 1965, Currie et al [CJS] proved that this is indeed the case for two particles (No-Interaction Theorem). The theorem has since been extended to an arbitrary number of particles by Leutwyler [LE]. All attempts to keep Minkowski's postulate, avoid The No-Interaction Theorem and merge the special theory with quantum mechanics have failed.

Dirac [DI1] was one of the first to openly change his mind about the fundamental nature of Minkowski's postulate. In 1963, he wrote:

> What appears to our consciousness is really a three-dimensional section of the four-dimensional picture. We must take a three-dimensional section to give us what appears to our consciousness at one time; at a later time we shall have a different three-dimensional section. The task of the physicist consists largely of relating events in one of these sections to events in another section referring to a later time. Thus the picture with four-dimensional symmetry does not give us the whole situation. This becomes particularly important when one takes into account the developments that have been brought about by quantum theory. Quantum theory has taught us that we have to take the process of observation into account, and observations usually require us to bring in the three-dimensional sections of the four-dimensional picture of the universe. ...
>
> when one looks at gravitational theory from the point of view of the sections, one finds that there are some degrees of freedom that drop out of the theory. The gravitational field is a tensor field with 10 components. One finds that six of the components

> are adequate for describing everything of physical importance and the other four can be dropped out of the equations. One cannot, however, pick out the six important components from the complete set of 10 in any way that does not destroy the four-dimensional symmetry.

The invariance requirement for Maxwell's equations can be satisfied by the Lorentz group without Minkowski's postulate (see [GZL]). We conclude that Minkowski's postulate imposes an additional condition on Einstein's special theory of relativity for one particle, but fails completely for two or more particles (at the classical level) and creates even more problems at the quantum level.

0.4 The 2.7 °K MBR and Mach's Principle

Two years after Dirac's paper, Penzias and Wilson discovered, the 2.7 °K microwave background radiation. We know that this radiation represents a unique preferred frame of rest, which exists throughout the universe and is available to all observers (see [PW]). This radiation is highly isotropic with anisotropy limits set at 0.001%. Furthermore, direct measurements have been made of the velocity of our Solar System and Galaxy (370 and 600 km/sec respectively, see Peebles [PE]). One can only speculate as to what impact this information would have had on the thinking of founding fathers, Einstein, Lorentz, Poincaré, Ritz and the many other serious investigators of the early 1900's who were concerned with truly understanding the foundations of electrodynamics and mechanics.

Peebles has conjectured that, the special theory is valid with or without a preferred frame of reference, so that the MBR does not violate the special theory. This statement is not obvious, in addition, general relativity predicts that at each point we can adjust our acceleration locally to find a freely falling frame where the special theory holds. In this frame, all observers with constant velocity are equivalent. Thus, according to the general theory we have an infinite family of freely falling frames. Within this context, the Penzias and Wilson findings show that, we can actually set the acceleration equal to zero.

Mach's principle was originally conceived to show that there is no difference between the rotation of the earth with respect to the fixed stars or the fixed stars with respect to the earth. We now realize that the fixed stars are not needed and the earth really does rotate. An accelerated charged particle experiences a damping force simultaneously with the moment of acceleration, so that a charged particle can be used to identify accelerating frames. Stated differently, charged particles always know when they are in an electromagnetic field (experience a force) and this effect cannot be transformed away.

0.5 Major Requirements

We have identified the following seven major requirements that must be faced directly if we want to design a consistent mathematical representation for physical reality. For any theory design;

1. the theory must be compatible with the two postulates of Einstein;
2. the theory must be compatible with Newtonian mechanics;
3. the theory must be compatible with the 2.7 °K mbr;
4. the theory must be compatible classical electrodynamics;
5. the theory must be compatible with quantum mechanics;
6. the theory must be mathematically consistent and,
7. the theory must at least be compatible with the results of general relativity.

In the remaining sections, we address the first three requirements and lay the foundations to address the others.

1 Theory Without Minkowski: Clocks and Observers

We begin with a simple model of an interacting system of n-particles defined in terms of physical variables and observed in an inertial frame by observer O. We assume that observer O is able to identify each particle and attach a vector $\mathbf{x}_i$ to the i^{th} particle, which denotes its spacial distance to the origin of O.

1.0.1 One-Particle Clock

First, we need to construct a unique clock for each particle. Let O observe the dynamics of particle i using coordinates $(\mathbf{x}_i, t)$. If $\mathbf{w}_i$ is the velocity of particle i as seen by O, let $\gamma^{-1}(\mathbf{w}_i) = \sqrt{1 - \mathbf{w}_i^2/c^2}$. The i^{th} particle proper time is defined by:

$$d\tau_i = \gamma^{-1}(\mathbf{w}_i)dt, \quad \mathbf{w}_i = \frac{d\mathbf{x}_i}{dt}, \quad d\tau_i^2 = dt^2 - \tfrac{1}{c^2}d\mathbf{x}_i^2. \tag{1.1}$$

We can also rewrite the last term to get:

$$dt^2 = d\tau_i^2 + \tfrac{1}{c^2}d\mathbf{x}_i^2, \Rightarrow cdt = \left(\sqrt{\mathbf{u}_i^2 + c^2}\right) d\tau_i, \quad \mathbf{u}_i = \frac{d\mathbf{x}_i}{d\tau_i} = \gamma(\mathbf{w}_i)\mathbf{w}_i \tag{1.2}$$

If we let $b_i = \sqrt{\mathbf{u}_i^2 + c^2}$, the second term in equation (1.2) becomes $cdt = b_i d\tau_i$. This leads to our first identity:

$$\frac{1}{c}\frac{d}{dt} \equiv \frac{1}{b_i}\frac{d}{d\tau_i} \tag{1.3}$$

This identity provides the correct way to define the relationship between the proper time and the observer time for the i^{th} particle. We see later that it represents a contact transformation, which leaves configuration space invariant and a canonical transformation which leaves phase space invariant. If we apply the identity to $\mathbf{x}_i$, we obtain our second new identity, which shows that the transformation leaves the configuration (tangent) space invariant:

$$\frac{\mathbf{w}_i}{c} = \frac{1}{c}\frac{d\mathbf{x}_i}{dt} \equiv \frac{1}{b_i}\frac{d\mathbf{x}_i}{d\tau} = \frac{\mathbf{u}_i}{b_i}.$$

The new particle coordinates are $(\mathbf{x}_i, \tau_i)$. In this representation, the position $\mathbf{x}_i$ is uniquely defined relative to O, while τ_i is uniquely defined by the i^{th} particle. Using $\gamma(\mathbf{w}_i) = H_i/m_ic^2$, we can also write $d\tau_i = (m_ic^2/H_i)\,dt$. The i^{th} particle momentum can be represented as $\mathbf{p}_i = m_i\gamma(\mathbf{w}_i)\mathbf{w}_i = m_i\mathbf{u}_i$, where m_i is the particle rest mass. Thus, the phase space variables are left invariant.

1.0.2 Many-Particle Clock

To construct the many-particle clock, we suppose the interacting particles have proper clocks τ_i, Hamiltonians H_i and total Hamiltonian $H = \sum_{i=1}^{n} H_i$. We define the effective mass M and total momentum $\mathbf{P}$ by

$$Mc^2 = \sqrt{H^2 - c^2\mathbf{P}^2}, \quad \mathbf{P} = \sum_{i=1}^{n} \mathbf{p}_i.$$

We can then represent H as $H = \sqrt{c^2\mathbf{P}^2 + M^2c^4}$.

Pryce, found that there are three possible definitions for the center of mass position vector. However, only one of them is canonical and independent of the frame in which it is defined. This is the natural and necessary choice if we want a theory that provides the same physics to all observers and is compatible with quantum mechanics. In our case, $\mathbf{X}$ is defined in the O frame by (see [LLP]):

$$\mathbf{X} = \frac{1}{H}\sum_{i=1}^{n} H_i\mathbf{x}_i + \frac{c^2\,(\mathbf{S}\times\mathbf{P})}{H\,(Mc^2+H)}, \tag{1.4}$$

where $\mathbf{S}$ is the global spin of the system of particles relative to O. (It is clear that (1.4) cannot represent the vector part of a four-vector.) If there is no interaction, S, H and M are constant, with no implicit dependence on the $\{\mathbf{x}_i\}$ variables, so that:

$$\{X_i, X_j\} = \sum_{k=1}^{n} \frac{\partial X_i}{\partial \mathbf{p}_k}\cdot\frac{\partial X_j}{\partial \mathbf{x}_k} - \frac{\partial X_j}{\partial \mathbf{p}_k}\cdot\frac{\partial X_i}{\partial \mathbf{x}_k} \equiv 0.$$

However, when interaction is present, S, H and M may all depend implicitly on the $\{\mathbf{x}_i\}$ variables, so that in general $\{X_i, X_j\} \neq 0$. Since $\mathbf{X}$ is the

canonical conjugate of $\mathbf{P}$, it precisely what we need for a consistent merge with quantum mechanics.

Let $\mathbf{V}$ be the velocity of $\mathbf{X}$ with respect to O. It follows that H also has the representation $H = Mc^2\gamma(\mathbf{V})$, so that $\gamma(\mathbf{V})^{-1} = (Mc^2/H)$. In this representation, we see that $d\tau = \gamma(\mathbf{V})^{-1}dt = (Mc^2/H)dt$ does not depend on the number of particles in the system. It follows that, as long as Mc^2/H is fixed, τ is invariant, so that the number of particles n, can increase or decrease without changing τ. (This means that number n is not conserved and, in some cases of physical interest, may even be a integer-valued random variable).

From $dt^2 = d\tau^2 + d\mathbf{X}^2/c^2$, we see that ($\mathbf{U} = d\mathbf{X}/d\tau$)

$$c^2dt^2 = \left(c^2 + \mathbf{U}^2\right)d\tau^2 \quad \Rightarrow \quad cdt = \left(\sqrt{c^2 + \mathbf{U}^2}\right)d\tau.$$

It is easy to see that $\mathbf{U} = \gamma(\mathbf{V})\mathbf{V}$, so that $\mathbf{U}$ is constant. If we define $b = \sqrt{\mathbf{U}^2 + c^2}$, we can write $cdt = bd\tau$. Since b is constant we have: $ct = b\tau$. For observer O' the same system has velocity $\mathbf{V}'$ for the center of mass and, by the same calculations, we obtain $ct' = b'\tau$, where $b' = \sqrt{\mathbf{U}'^2 + c^2}$. This shows that a unique (operational) measure of time is available to all observers. Furthermore, τ differs from t (respectively t'), by a constant scale factor. Thus, all observers may uniquely define the local-time of the center of mass for the system of particles (independent of their chosen inertial frame). We also obtain our third identity:

$$\frac{1}{c}\frac{d}{dt} \equiv \frac{1}{b}\frac{d}{d\tau} \equiv \frac{1}{b_i}\frac{d}{d\tau_i} \tag{1.5}$$

Theorem 1.1. *If O is observing any system of particles, there are two sets of global variables available: $(\mathbf{X}, t)$ and $(\mathbf{X}, \tau)$. Use of $(\mathbf{X}, t)$ provides a relative definition of time and a constant speed of light; while use of $(\mathbf{X}, \tau)$ provides a unique definition of time and a relative definition of the speed of light (b).*

Proof. The first part is clear. To prove the second statement, from above, we see that any other observer O' investigating the same system of particles also has two sets of global variables available: $(\mathbf{X}', t')$ with a constant speed

of light and $(\mathbf{X}', \tau)$ with b' relative. We are done if we can show that Einstein's first postulate holds.

Let $\mathbf{W}$ be the relative velocity between observer O and O'. Since τ is the same for both we only need the relationship between the two scale factors b and b' to satisfy the first postulate. Starting with $t' = \frac{b'}{c}\tau = \gamma(\mathbf{W})\left(\frac{b}{c}\tau - \mathbf{X}\cdot\mathbf{V}/c^2\right)$, we see that, since $\mathbf{U} = (\mathbf{X}/\tau)$, we get:

$$b' = \gamma(\mathbf{W})\left[b - (\mathbf{X}/\tau)\cdot(\mathbf{W}/c)\right] = \gamma(\mathbf{W})\left(b - \mathbf{U}\cdot\mathbf{W}/c\right).$$

A similar calculation shows that $b = \gamma(\mathbf{W})\left(b' - \mathbf{U}'\cdot\mathbf{W}/c\right)$. This shows that each observer can have direct access to all information available to any other observer once they know their relative velocities. Thus the first postulate of Einstein is satisfied at the global level. □

Corollary 1.2. *The two global sets of variables produce mathematically equivalent theories, but do not produce physically equivalent theories.*

Theorem 1.3. *The special theory of Einstein holds for any many-particle system and is independent of the Minkowski postulate.*

This result is fundamental to our approach, since we do not require that the particle coordinates transform as four-vectors. Thus, the no-interaction theorem does not apply. In the following section, we study the dynamics of the particle system.

2 The Dynamics

In this section, we focus on the external and internal dynamics of our system of particles.

2.1 Poincaré algebra

If we let $\mathbf{L}$ be the generator of pure Lorentz transformations (boost) and define the total angular momentum $\mathbf{J}$ by

$$\mathbf{J} = \sum_{i=1}^{n} \mathbf{x}_i \times \mathbf{p}_i,$$

we obtain the following Poisson Bracket relations characteristic of the Lie algebra for the Poincaré group, when we use the time t of our observer O:

$$\begin{aligned}
&\frac{d\mathbf{P}}{dt} = \{H, \mathbf{P}\} = 0 \qquad \frac{d\mathbf{J}}{dt} = \{H, \mathbf{J}\} = 0 \qquad \{P_i, P_j\} = 0 \\
&\{J_i, P_j\} = \varepsilon_{ijk} P_k \qquad \{J_i, J_j\} = \varepsilon_{ijk} J_k \qquad \{J_i, L_j\} = \varepsilon_{ijk} L_k \qquad (2.1) \\
&\frac{d\mathbf{L}}{dt} = \{H, \mathbf{L}\} = -\mathbf{P} \qquad \{P_i, L_j\} = \delta_{ij} \frac{H}{c^2} \qquad \{L_i, L_j\} = \varepsilon_{ijk} \frac{J_k}{c^2}.
\end{aligned}$$

It is easy to see that M commutes with H, $\mathbf{P}$, and $\mathbf{J}$, and to show that M commutes with $\mathbf{L}$.

2.1.1 Canonical Hamiltonian

If we treat the system of particles as a single entity, then $(\mathbf{X}, \mathbf{P})$ are the natural phase space variables for the external system dynamics. In this case, if $W(\mathbf{X}, \mathbf{P})$ is a dynamical parameter in $\mathbf{X}$ and $\mathbf{P}$, the time evolution of W is defined by:

$$\frac{dW}{dt} = \{H, W\} = \frac{\partial H}{\partial \mathbf{P}} \cdot \frac{\partial W}{\partial \mathbf{X}} - \frac{\partial H}{\partial \mathbf{X}} \cdot \frac{\partial W}{\partial \mathbf{P}}. \qquad (2.2)$$

In order represent the dynamics using the proper time of the system, we use the representation $d\tau = (Mc^2/H)dt$, so that:

$$\frac{dW}{d\tau} = \frac{dt}{d\tau}\frac{dW}{dt} = \frac{H}{Mc^2}\{H, W\} = \left(\frac{H}{Mc^2}\frac{\partial H}{\partial \mathbf{P}}\right) \cdot \frac{\partial W}{\partial \mathbf{X}} - \left(\frac{H}{Mc^2}\frac{\partial H}{\partial \mathbf{X}}\right) \cdot \frac{\partial W}{\partial \mathbf{P}}.$$

The ratio H/Mc^2 is constant and Mc^2 is a well-defined (invariant) for the system, so we can determine the canonical Hamiltonian K, related to τ by:

$$\{K, W\} = \frac{H}{Mc^2}\{H, W\}, \quad K|_{\mathbf{P}=0} = H|_{\mathbf{P}=0} = Mc^2.$$

In this case:

$$\begin{aligned}
\{K, W\} &= \left[\frac{H}{Mc^2}\frac{\partial H}{\partial \mathbf{P}}\right]\frac{\partial W}{\partial \mathbf{X}} - \left[\frac{H}{Mc^2}\frac{\partial H}{\partial \mathbf{X}}\right]\frac{\partial W}{\partial \mathbf{P}} \\
&= \frac{\partial}{\partial \mathbf{P}}\left[\frac{H^2}{2Mc^2} + a\right]\frac{\partial W}{\partial \mathbf{X}} - \frac{\partial}{\partial \mathbf{X}}\left[\frac{H^2}{2Mc^2} + a'\right]\frac{\partial W}{\partial \mathbf{P}},
\end{aligned}$$

we get that $a = a' = \frac{1}{2}Mc^2$, so that

$$K = \frac{H^2}{2Mc^2} + \frac{Mc^2}{2} = \frac{\mathbf{P}^2}{2M} + Mc^2, \quad \text{and} \quad \frac{dW}{d\tau} = \{K, W\}. \tag{2.3}$$

Thus, K looks like the standard (Newtonian) Hamiltonian except for the Mc^2 term.

2.1.2 Proper time Poincaré algebra

We can use the same definitions for $\mathbf{P}$, $\mathbf{J}$, and $\mathbf{L}$ to obtain our new commutation relations:

$$\begin{aligned}
&\frac{d\mathbf{P}}{d\tau} = \{K, \mathbf{P}\} = 0, \qquad \frac{d\mathbf{J}}{d\tau} = \{K, \mathbf{J}\} = 0, \quad \{P_i, P_j\} = 0, \\
&\{J_i, P_j\} = \varepsilon_{ijk} P_k, \qquad \{J_i, J_j\} = \varepsilon_{ijk} J_k, \qquad \{J_i, L_j\} = \varepsilon_{ijk} L_k, \\
&\frac{d\mathbf{L}}{d\tau} = \{K, \mathbf{L}\} = \tfrac{-H}{Mc^2}\mathbf{P}, \quad \{P_i, L_j\} = \tfrac{-H}{c^2}\delta_{ij}, \quad \{L_i, L_j\} = \tfrac{-J_k}{c^2}\varepsilon_{ijk}.
\end{aligned} \tag{2.4}$$

We see again that, except for a (constant) change of scale, we obtain the same Lie algebra for the Poincaré group. Thus, the replacement of t with τ still produces a relativistic theory.

2.1.3 The $t \to \tau$ contact group

The mapping between t and τ is a member of the family of contact groups, often used in celestial mechanics (see [WH]). Contact transformations are sometimes called tangency transformations in mechanics, because they leave invariant the tangent at the point of contact. For our case, an explicit representation is easy:

$$\begin{aligned}
&d\tau = \gamma^{-1} dt = \gamma'^{-1} dt' \Rightarrow \\
&dt = \gamma d\tau \text{ and } dt' = \gamma' d\tau
\end{aligned}$$

These transformations are clearly invertible. Since the observer frames are inertial, we have that $t = \gamma\tau$ and $t' = \gamma'\tau$. Thus the transformation $t \to \tau$

induces the contact mapping of $\mathbf{C}^{-1}[t, \tau] : (O,t) \to (O,\tau)$. (See [GZL] pg 1312, for the general case.)

Let observer O' with time t' observe the same system of particles. From this frame the total Hamiltonian is H'. One can also construct $\mathbf{P}'$ and M', leading to the same form for the commutation relations as in (2.4).

Let the contact maps from $(O,\tau) \to (O,t)$ and from $(O',\tau) \to (O',t')$ be denoted by $\mathbf{C}[t, \tau]$ and $\mathbf{C}[t', \tau]$ respectively. Let $\mathcal{P}(O',O)$ be the Poincaré map from $O \to O'$.

Theorem 2.1. *The system of particles as seen by an observer at O is related to that of an observer at O' by the Zachary transformation:*

$$\begin{aligned} &O'(\mathbf{X}', \tau) = \mathcal{Z}[O', O, \tau]O(\mathbf{X}, \tau) \\ &= \mathbf{C}[t', \tau]\mathcal{P}(O', O)\mathbf{C}^{-1}[t, \tau]O(\mathbf{X}, \tau). \end{aligned} \tag{2.5}$$

Remark 2.2. *The above transformation is named for our deceased colleague Woodford W. Zachary (see [GZL], equation (5.21)).*

Proof. The proof follows since the diagram below is commutative.

$$\begin{array}{ccc} O(\mathbf{X}, t) & \xrightarrow{\mathcal{P}} & O'(\mathbf{X}', t') \\ \mathbf{C}^{-1}[t, \tau] \uparrow & & \downarrow \mathbf{C}[t', \tau] \\ O(\mathbf{X}, \tau) & \xrightarrow{\mathcal{Z}} & O'(\mathbf{X}', \tau) \end{array}$$

□

Since K does not depend on the center-of-mass position $\mathbf{X}$, it is easy to see that

$$\mathbf{U} = \frac{d\mathbf{X}}{d\tau} = \frac{\partial K}{\partial \mathbf{P}} = \frac{\mathbf{P}}{M} = \frac{1}{M}\sum_{i=1}^{n} \mathbf{p}_i = \frac{1}{M}\sum_{i=1}^{n} m_i \mathbf{u}_i = \frac{1}{M}\sum_{i=1}^{n} m_i \frac{d\mathbf{x}_i}{d\tau_i}. \tag{2.6}$$

For the O' observer, the same calculation leads to:

$$\mathbf{U}' = \frac{d\mathbf{X}'}{d\tau} = \frac{\partial K}{\partial \mathbf{P}'} = \frac{\mathbf{P}'}{M'} = \frac{1}{M'}\sum_{i=1}^{n} \mathbf{p}'_i = \frac{1}{M'}\sum_{i=1}^{n} m'_i \mathbf{u}'_i = \frac{1}{M'}\sum_{i=1}^{n} m'_i \frac{d\mathbf{x}'_i}{d\tau_i}. \quad (2.7)$$

We now observe that

$$dt = \frac{H_i}{m_i c^2} d\tau_i = \frac{H}{Mc^2} d\tau \quad \Rightarrow \quad \frac{m_i}{M}\frac{d}{d\tau_i} = \frac{H_i}{H}\frac{d}{d\tau}.$$

Thus, we can replace (2.6) and (2.7) by:

$$\frac{d\mathbf{X}}{d\tau} = \frac{\partial K}{\partial \mathbf{P}} = \frac{\mathbf{P}}{M} = \frac{1}{M}\sum_{i=1n}^{n} \mathbf{p}_i = \frac{1}{M}\sum_{i=1}^{n} m_i \mathbf{u}_i = \frac{1}{H}\sum_{i=1}^{n} H_i \frac{d\mathbf{x}_i}{d\tau} \quad (2.8)$$

and

$$\frac{d\mathbf{X}'}{d\tau} = \frac{\partial K}{\partial \mathbf{P}'} = \frac{\mathbf{P}'}{M'} = \frac{1}{M'}\sum_{i=1}^{n} \mathbf{p}'_i = \frac{1}{M'}\sum_{i=1}^{n} m'_i \mathbf{u}'_i = \frac{1}{H'}\sum_{i=1n}^{n} H'_i \frac{d\mathbf{x}'_i}{d\tau}. \quad (2.9)$$

Since the H_i (respectively H'_i) do not depend on τ, we can integrate both equations to get:

$$\mathbf{X} = \frac{1}{H}\sum_{i=1n}^{n} H_i \mathbf{x}_i + \mathbf{Y} \quad \text{and} \quad \mathbf{X}' = \frac{1}{H'}\sum_{i=1n}^{n} H'_i \mathbf{x}'_1 + \mathbf{Y}',$$

where $\mathbf{Y}$ and $\mathbf{Y}'$ are constants of integration. (This shows that the canonical Hamiltonian determines the canonical position up to a constant.)

To see directly that the clock transformation is also a canonical change of variables (time), which leaves phase space invariant, we have the following theorem.

Theorem 2.3. *There exists a function* $S = S(\mathbf{X}, \mathbf{P}, \tau)$ *such that*

$$\mathbf{P} \cdot d\mathbf{X} - H dt \equiv \mathbf{P} \cdot d\mathbf{X} - K d\tau + dS.$$

Proof. Set $S = [Mc^2 - K]\tau$. An easy calculation, using the fact that both Mc^2 and K are conserved quantities, shows that $dS = [Mc^2 - K]d\tau$. An additional easy calculation gives the result. □

We note that

$$\sum_{i=1}^{n}[\mathbf{p}_i \cdot d\mathbf{x}_i - H_i dt] = \sum_{i=1}^{n}\mathbf{p}_i \cdot d\mathbf{x}_i - \sum_{i=1}^{n}H_i dt = \sum_{i=1}^{n}\mathbf{p}_i \cdot d\mathbf{x}_i - H dt.$$

This result and $dS = [Mc^2 - K]d\tau$ is sufficient to justify the following:

Corollary 2.4. *There exists a function* $S = S(\{\mathbf{x}_i\}, \{\mathbf{p}_i\}, \tau)$ *such that*

$$\sum_{i=1}^{n}\mathbf{p}_i \cdot d\mathbf{x}_i - H dt \equiv \sum_{i=1}^{n}\mathbf{p}_i \cdot d\mathbf{x}_i - K d\tau + dS.$$

Definition 2.5. *A theory is said to be Einsteinian if at least one representation exists, which satisfies the two postulates of the special theory.*

Theorem 2.6. *Any closed system of interacting particles is Einsteinian and independent of the Minkowski postulate. Furthermore, there always exists two distinct sets of inertial frame coordinates for each observer, to describe each particle in the system and the system as a whole. The following holds:*

1. *In one frame, the speed of light is an invariant upper bound and time is relative, while in the other, time is invariant and the speed of light b, is relative with no upper bound.*

2. *For the whole system and for each particle, the equations of motion are mathematically equivalent.*

We have already proven all but one part of the above theorem. The next two sections complete the theorem.

2.2 External Dynamics

If the system is viewed from an external perspective as if it is one particle interacting with an external source, it suffices to assume the interaction is via a potential $V(\mathbf{X})$. We can add V to the equation for H, to get:

$$\begin{aligned} &H = \sqrt{c^2\mathbf{P}^2 + M^2c^4} + V(\mathbf{X}) = H_0 + V(\mathbf{X}) \Rightarrow \\ &\frac{d\mathbf{X}}{dt} = \frac{c^2\mathbf{P}}{H_0} \quad \textit{and} \quad \frac{d\mathbf{P}}{dt} = -\nabla V(\mathbf{X}). \end{aligned} \tag{2.10}$$

For comparison, if we use the proper clock, we get:

$$\begin{aligned} K &= \frac{H^2}{2Mc^2} + \frac{Mc^2}{2} \Rightarrow \frac{d\mathbf{X}}{d\tau} = \frac{\partial K}{\partial \mathbf{P}} = \frac{H}{Mc^2}\frac{c^2\mathbf{P}}{H_0} = \frac{b}{c}\frac{d\mathbf{X}}{dt}, \\ \frac{d\mathbf{P}}{d\tau} &= \frac{\partial K}{\partial \mathbf{X}} = -\frac{H}{Mc^2}\nabla V(\mathbf{X}) = \frac{b}{c}\frac{d\mathbf{P}}{dt}. \end{aligned} \tag{2.11}$$

Comparison of (2.10) and (2.11) shows that the two clocks give mathematically equivalent equations of motion for the global dynamics.

2.3 Internal Dynamics

We now focus on the motion of one particle as seen from the global internal point of view, assuming no external interaction. For our purposes, it is sufficient to assume a specific assumption about the internal interactions and exclude vector potentials (see [GZL]). We assume

$$H_i = H_{i0} + V_i = \sqrt{c^2\mathbf{p}_i^2 + m_i^2c^4} + V_i, \tag{2.12}$$

where $V_i = \sum_{j\neq i} V_{ji}$. We assume that V_{ji} represents the action of the retarded potential of the j-th particle on the i-th particle. Since, $V_{ij} \neq V_{ji}$, we do not include the customary factor of $\frac{1}{2}$ in our definition of the potential for particle i. In this case, we have

$$\begin{aligned} \mathbf{v}_i &= \frac{d\mathbf{x}_i}{d\tau} = \frac{\partial K}{\partial \mathbf{p}_i} = \frac{H}{Mc^2}\frac{c^2\mathbf{p}_i}{H_{io}} = \frac{b}{c}\frac{c^2\mathbf{p}_i}{H_{io}} = \frac{b}{c}\frac{d\mathbf{x}_i}{dt}, \\ \frac{d\mathbf{p}_i}{d\tau} &= -\frac{\partial K}{\partial \mathbf{x}_i} = -\left(\frac{b}{c}\right)\sum_{k=1}^{n}\nabla_i V_k = \frac{b}{c}\frac{d\mathbf{p}_i}{dt}. \end{aligned} \tag{2.13}$$

Where we have use the relationship $H/Mc^2 = (b/c)$. Rewriting the potentials, we also have:

$$\frac{d\mathbf{p}_i}{d\tau} = -\frac{b}{c}\sum_{k=1}^{n}\nabla_i V_k \Rightarrow \frac{c}{b}\frac{d\mathbf{p}_i}{d\tau} = -\sum_{k=1}^{n}\nabla_i V_k = -\nabla_i V_i - \sum_{k\neq i}^{n}\nabla_i V_k. \tag{2.14}$$

We first note that, $\nabla_i V_k = \nabla_i V_{ik}$. Furthermore, each term is referred to the present time τ. However, the potentials are with respect to the retarded

time in the $\mathbf{x}_i$ variable (i.e., $\mathbf{x}_i = \mathbf{x}_i(\tau')$). Thus, we need to relate ∇_i at fixed τ to ∇_i at fixed τ'. Reflection shows that (mathematically) this is equal, with the opposite sign, to the retarded action of particle i (at the past time τ') on particle k (at the present time τ). Thus we have: $\nabla_i V_{ik} = -\nabla_k V_{ik}$. If we set $\mathbf{F}_i = -\nabla_i V_i$ and $\mathbf{F}_{ik} = -\nabla_k V_{ik}$, we can write equation (2.14) as:

$$\frac{c}{b}\frac{d\mathbf{p}_i}{d\tau} = \mathbf{F}_i - \sum_{k\neq i}^{n} \mathbf{F}_{ik}. \tag{2.15}$$

Let us first observe that, if we sum over all i, we get:

$$\frac{c}{b}\sum_{i=1}^{n}\frac{d\mathbf{p}_i}{d\tau} = \sum_{i=1}^{n}\mathbf{F}_i - \sum_{i=1}^{n}\sum_{k\neq i}^{n}\mathbf{F}_{ik} = \sum_{i=1}^{n}\mathbf{F}_i - \sum_{k=1}^{n}\mathbf{F}_k = 0.$$

This shows that

$$\frac{c}{b}\sum_{i=1}^{n}\frac{d\mathbf{p}_i}{d\tau} = \frac{c}{b}\frac{d\mathbf{P}}{d\tau} = 0,$$

so that equation (2.15) is consistent with conservation of total momentum for our system of particles.

We now use our identity in (2.15):

$$\frac{1}{c}\frac{d}{dt} \equiv \frac{1}{b}\frac{d}{d\tau}$$

along with the first part of equation (2.13) and equation (2.15) to see that

$$\frac{d\mathbf{x}_i}{d\tau} = \frac{b}{c}\frac{d\mathbf{x}_i}{dt} \text{ and,}$$

$$\frac{d\mathbf{p}_i}{dt} = \mathbf{F}_i - \sum_{k\neq i}^{n}\mathbf{F}_{ik}. \tag{2.16}$$

Thus, the velocities and forces are mathematically equivalent. However, they are clearly not physically equivalent. This concludes our proof of Theorem 3.6.

2.4 The Clock Relationship

There is a basic relationship between the global system clock and the clocks of the individual particles. To derive this relationship, return to our definition of the global Hamiltonian K and let W be any observable. Then

$$\frac{dW}{d\tau} = \{K, W\} = \frac{H}{Mc^2}\{H, W\} = \frac{H}{Mc^2}\sum_{i=1}^{n}\{H_i, W\}$$
$$= \frac{H}{Mc^2}\sum_{i=1}^{n}\frac{m_i c^2}{H_i}\left[\frac{H_i}{m_i c^2}\{H_i, W\}\right] = \sum_{i=1}^{n}\frac{Hm_i}{MH_i}\{K_i, W\}. \quad (2.17)$$

Using the (easily derived) fact that $d\tau_i/d\tau = Hm_i/MH_i = b_i/b$, we get

$$\frac{dW}{d\tau} = \sum_{i=1}^{n}\frac{d\tau_i}{d\tau}\{K_i, W\}. \quad (2.18)$$

Equation (2.18) allows us to relate the global system dynamics to the local systems dynamics. Let us combine equations (2.17) and (2.18), to get our third identity:

$$d\tau\{K, W\} \equiv \sum_{i=1}^{n} d\tau_i\{K_i, W\} \quad \Rightarrow \quad d\tau K^P = \sum_{i=1}^{n} d\tau_i K_i^P. \quad (2.19)$$

Where the last equation is strictly defined with the Poisson brackets. This provides the basis for a many particle relativistic quantum theory with a universal wave function, using the transition to Heisenberg brackets on both sides (geometric quantization).

3 Newtonian Clock

A fundamental conclusion of the last two sections is that, for any system of particles, there always exists a unique observer-independent measure of time. One consequence is the following theorem.

Theorem 3.1. *Suppose that the observable universe is representable in the sense that the observed ratio of mass energy to total energy is constant and independent of our observed portion of the universe. Then the universe has a unique clock that is available to all observers.*

Under the stated conditions H/Mc^2 is constant, so that the proof follows. The assumption of Theorem 3.1 is equivalent to that of homogeneity and isotropy of the energy and mass density of the universe.

Theorem 3.2. *(Peebles) Suppose all observers choose a frame that is at rest with respect to the $2.7°K$ microwave background radiation, then all laws will be invariant and not just covariant with respect to Lorentz transformations.*

In the study of physical systems one is sometimes not interested in the behavior of the global system, but only in some subsystem. The cluster decomposition property is a requirement of any theory purporting to be a possible representation of the real world. Basically this is the property that, if any two or more subsystems become widely separated, then they may be treated as independent systems (clusters).

Theorem 3.3. *Suppose the system of particles can be decomposed into two or more clusters. Then there exists a unique (local) clock and corresponding canonical Hamiltonian for each cluster.*

Proof. We assume that the subsystems are sufficiently separated, so that all observers can agree that they are distinct. In this case, each observer can identify effective masses M_1, M_2 and Hamiltonians H_1, H_2. It follows that $d\tau_1 = [(M_1c^2)/H_1]dt$ and $d\tau_2 = [(M_2c^2)/H_2]dt$, so that each observer can construct a local-time theory for each cluster. □

Actually, the theorem is true without the assumption that the systems are weakly interacting. This makes the theorem less difficult to apply than the various phenomenological approaches, which require both model justification and consistency analysis prior to use. This theorem also allows us to prove a weaker version of Theorem (3.1), in the sense that we replace the assumption of homogeneity and isotropy of the energy and mass density for a possible infinite universe by finite energy and mass density for a possibly inhomogeneous universe.

Theorem 3.4. *Suppose the universe has finite mass and energy, and that each observer can choose a local inertial frame from which his/her region of the universe is at rest relative to the observed system. Then there exists a unique proper clock for the universe.*

Proof. Applying the cluster decomposition theorem, our observer can identify masses M_1 for his/her region of the universe and M_2 for the complement region, along with Hamiltonians H_1 and H_2. It follows that $H = H_1 + H_2$, $M = M_1 + M_2$ and $d\tau = [(Mc^2)/H]dt$ define the total mass, Hamiltonian and proper clock for the universe. We can now construct our canonical proper-time Hamiltonian K. Since M and H are fixed, and invariant for all observers, we see that both K and τ are unique and invariant for all observers. □

Remark 3.5. *It should be remarked that M_i and H_i, $i = 1, 2$, will vary with observers, reflecting the non-uniqueness of inertial frames.*

3.1 The Big Bang

The currently accepted cosmological model for the universe assumes that our universe began around 13.8 billion years ago with a big bang. From a minimalist point of view, this model should be consistent with our current experimentally obtained understanding about the universe:

1. Whenever an antiparticle is observed in experiment, we always find that it is also accompanied by a particle.

2. Whenever an interaction is observed in experiment, a complete analysis always shows that momentum, angular momentum and energy are conserved.

As currently postulated, there is no known way that conservation of energy can be maintained with the current big bang model for the universe. However, there are no compelling reasons that the remaining laws must also be violated. In this section, we suggest a slight alteration of the beginning, which brings the model closer to our experimental understanding, while only requiring non-conservation of energy.

We first revisit our conceptual view of the real numbers and their representation. Recall that a field is a set A that has two binary operations $\oplus$ and $\odot$ that satisfies all our common experience with real numbers. Formally:

Definition 3.6. *The real numbers is a triplet $(\mathbb{R}, +, \cdot)$, which is a field, with 0 as the additive identity (i.e., $a + 0 = a$ for all $a \in \mathbb{R}$) and 1 as the multiplicative identity (i.e., $a \cdot 1 = a$ for all $a \in \mathbb{R}$).*

This structure was developed by mathematicians without regard to its possible use in physics. As a consequence the asymmetry in this structure went unnoticed and physicists used it without investigation until Santilli [SA] defined the isodual number field. His definition is more general. For our purpose, we only need the following.

Definition 3.7. *The isodual real numbers $(\hat{\mathbb{R}}, +, *)$ is a field, with $0 = \hat{0}$ as the additive identity (i.e., $\hat{a} + \hat{0} = \hat{a}$ for all $-a = \hat{a} \in \hat{\mathbb{R}}$) and $\hat{1} = -1$ as the multiplicative identity (i.e., $\hat{a} * \hat{1} = (-a)(-1)(-1) = \hat{a}$ for all $\hat{a} \in \hat{\mathbb{R}}$).*

Example 3.8. *A simple example from quantum theory is the following: the evolution of particle is defined on a Hilbert space $\mathcal{H}$ over the complex numbers $\mathbb{C} = \mathbb{R} + i\mathbb{R}$, with Hamiltonian H by the equation:*

$$i\hbar \frac{\partial \psi}{\partial t} = H\psi.$$

The conjugate equation is:

$$-i\hbar \frac{\partial \psi^*}{\partial t} = H\psi^*.$$

If we use $\hat{\mathbb{C}}$ as our number field, we can write the above equation as:

$$\hat{i} * \hat{\hbar} * \frac{\partial \psi^*}{\partial \hat{t}} = H\psi^*$$

Thus, this approach allows us to naturally view anti-particles as time reversed particles, with their evolution defined on $\mathcal{H}^*$ over $\hat{\mathbb{C}}$.

Remark 3.9. *Santilli [SA] has shown that charge conjugation and isoduallity are equivalent for the particle-antiparticle symmetry operation. However, isoduallity allows us to view the existence of antimatter and charge conservation as fundamental aspects of the universe, while also explaining why large amounts of antimatter are not found in this universe.*

In the diagram below, we provide a new picture of the big bang beginning. In this case, two universes are created, one going forward in τ_N and one going backward in τ_N (Newtonian time).

$$\xleftarrow{-\tau_N=\hat{\tau}_N<0} \Big|_{\tau_N=0} \xrightarrow{\tau_N>0}$$

This view has the following advantages:

1. We obtain a natural arrow for time, with a zero initial point.
2. We obtain a natural explanation for the lack of antimatter in this universe.
3. We obtain antiparticles as particles moving backward in proper time.
4. We obtain conservation of momentum and angular momentum.
5. We obtain conservation of charge.

It is important to be clear that our assumption does not imply that there are any other symmetries or necessary similarities between the two universes.

4 Conclusion

In this paper we have investigated the role of time in physics and analyzed Minkowski's third postulate for the special theory of relativity. This has led us to conclude that, although mathematically convenient, Minkowski's postulate is physically unjustified and the major problem preventing Einstein's special theory of relativity from fully accounting for Newtonian mechanics and from merging with quantum mechanics. We have investigated time's

natural role in directing the flow of physical reality and shown that this view is consistent with the first two postulates of Einstein, Peebles conjecture and Newton's universal time. We have also shown that, by introducing a symmetric view of the number line, we can provide a version of the big bang that gives an arrow for time, conservation of charge, conservation of linear and angular momentum. We can also explain the lack antimatter in the universe, so that the only known violated physical law is conservation of energy.

The most important conclusion from this investigation is that the interpretation of experimental observations is not unique. In order to make this last statement explicit in a very powerful manner, recall that many measurements are based on the dimensionless ratio $\beta = \mathbf{w}/c$. However, $\mathbf{w}/c \equiv \mathbf{u}/b$, so we see that measurements of velocity and the speed of light for distant objects are totally ambiguous. For example, ([PH], pp. 556-561), the red shift factor z, used to determined distances in astronomy, is defined by:

$$z = \sqrt{\frac{1+\frac{\mathbf{w}}{c}}{1-\frac{\mathbf{w}}{c}}} - 1 \equiv \sqrt{\frac{1+\frac{\mathbf{u}}{b}}{1-\frac{\mathbf{u}}{b}}} - 1.$$

We thus conclude that distant objects may have much higher velocities and light may have a velocities higher then c, without any contradiction.

References

[AG] M. Aizenman, R. Graham, Nucl. Phys. B 225, 261 (1983).

[AR] V. L. Arnold, (English translation): Russian Math. Surveys **53** (1) (1998) 229?236.

[AS] A. Salam, *Overlapping divergence and the S-matrix*, Phys. Rev. **82**, (1951) 217-227.

[BR] H.R Brown, Eur. J. Phys. **26**, S85 (2005).

[BT] B. Bakamjian and L. H. Thomas, Phys. Rev. **92**, 1300 (1953).

[CJS] D. G. Currie, T. F. Jordan, and E. C. G. Sudarshan, Rev. Mod. Phys. **35**, 350 (1963).

[D] P. A. M. Dirac, *Classical theory of radiating electrons*, Proceedings of the Royal Soc. of London A **167** (1938) 148-168.

[DI] P. A. M. Dirac, Rev. Mod. Phys. **21**, 392 (1949).

[DI1] P. A. M. Dirac, Sci. Amer. **208**, 45 (1963).

[DY] F. Dyson, *The S-matrix in quantum electrodynamics*, Phys. Rev. **75** (1949), 1736-1755.

[E1] A. Einstein, Ann. d. Phys. **17**, 891 (1905).

[E2] A. Einstein, Jahrbuch Radioaktivitat **V**, 422 (1907) (Berichtigungen).

[EG] A. Einstein and M. Grossmann, *Entwurf einer verallgemeinerten Relativitätstheorie und einer Theorie der Gravitation*, Leipzig, Berlin: Teubner, (1913).

[EL1] A. Einstein and J Laub, *Über die elektromagnetischen Grundgleichugen für bewegte Köper*, Ann. d. Phys. **33**(8), 532-540 (1908).

[EL2] A. Einstein and J Laub, *Über die im elektromagnetischen Felde auf ruhende Köper ausgeübten ponderomotorischen Kräfte*, Ann. d. Phys. **331**(8), 551-550 (1908).

[ETB] E. T. Bell, *Men of Mathematics* , Simon & Schuster, New York, (1937).

[FE] R. P. Feynman, Phys. Rev. **81**, 108 (1951).

[FO] J. Fröhlich, Nucl. Phys. B 200, 281 (1982).

[GZ1] T. L. Gill and W. W. Zachary, *Foundations for relativistic quantum theory I: Feynman's operator calculus and the Dyson conjectures*, Journal of Mathematical Physics **43** (2002), 69-93.

[GZ2] T. L. Gill and W. W. Zachary, *Functional Analysis and the Feynman operator Calculus*, Springer New York, (2016).

[GZ3] T. L. Gill and W. W. Zachary, *Two Mathematically Equivalent Versions of Maxwell?s Equations, Foundations of Physics*, (online) DOI 10.1007/s10701-009-9331-8, (2011).

[GZL] T.L. Gill, W.W. Zachary and J. Lindesay, *The Classical Electron Problem*, Found. Phys. **31**, 1299 (2001).

[L1] H. A. Lorentz, *Archives Neerlandaises des Sciences Exactes et Naturelles*, **25**, 353 (1892).

[L2] H. A. Lorentz, *The Theory of Electrons* B. G. Teubner, Leipzig, 1906; (reprinted by Dover, New York, 1952).

[LE] H. Leutwyler. *A no-interaction theorem in classical relativistic hamiltonian particle mechanics*, Nuovo Cim., **37**, 556 (1965).

[LLP] G. Longhi, L. Lusanna, and J. M. Pons, J. Math. Phys. 30, 1893 (1989).

[LS] H. Leutwyler and J. Stern, Ann. Phys. (N. Y.) **112**, 94 (1978).

[MI] H. Minkowski, Physikalische Zeitschrift **10**,104 (1909).

[PA] A. Pais, *Subtle is the lord: the science and life of Albert Einstein*, Oxford University Press (1982).

[PE] P.J.E. Peebles, *Principles of Physical Cosmology*, Princeton University Press, London (1993).

[PH] C. Payne-Gaposchkin and K. Haramundanis, *Introduction to Astronomy*, Prentice-Hall Inc., Englewood Cliffs, NJ, second Edition, (1970).

[PO1] H. Poincaré, *Science and Hypothesis* (1902); reprinted in *The Foundations of Science* New York: Science Press (1921).

[PO2] H. Poincaré, C.R. Acad. Sci. Paris **140**, 1504 (1905).

[PO3] H. Poincaré, *Sur la dynamique de l'électron* , Rendiconti del Circolo matematico Rendiconti del Circolo di Palermo, **21**, 129-176 (1906).

[PW] A. A. Penzias and R. W. Wilson, Ap. J. **142**, 419 (1965).

[PY] M.H.L. Pryce, Proc. Roy. Soc. London A **195**, 400 (1948)..

[RA] M. Radovan *On the Nature of Time*, arXiv:1509.01498

[SA] R. M. Santilli, *Isonumbers and genonumbers of dimension 1, 2, 4, 8, their isoduals, and pseudoduals, and ?hidden numbers? of dimension 3, 5, 6, 7*, Algebras, Groups and Geometries, Vol. **10**, 273?322 (1993).

[SC] J. Schwinger, Found. Phys. **13**, 2573 (1998).

[SE] J. Serrin, *An Appreciation of Clifford Truesdell*, appeared in *The Rational Spirit in Modern Continuum Mechanics* pp 31?38, C. S. Man and R. L. Fosdick (eds.), Kluwer Academic Publishers, (2004).

[SM] E. C. G. Sudarshan and N. Mukunda, *Classical Dynamics: A Modern Perspective.* John Wiley & Sons, New York (1974).

[SO] A.D. Sokal, Ann. Inst. Henri Poincare Sect. A 37, 13 (1982).

[SW] S. Schweber, *QED And The Men Who Made It* , Princeton University Press, London (1994).

[W] E. Wigner, *The Unreasonable Effectiveness of Mathematics in the Natural Sciences*, Communications in Pure and Applied Mathematics **13**(1) (1960).

[WA] S. Walters, In: Gonner, H., Renn, J., Ritter, J. (eds.) *The Expanding Worlds of General Relativity.* Einstein Studies, vol. 7, pp. 45-86. Birkhäuser, Boston (1999).

[WF] J.A. Wheeler and R.P. Feynman, *Interaction with the absorber as the mechanism of radiation* Rev. Mod. Phys. **17** (1949) 157-181.

[WH] E. T. Whittaker, *A Treatise on the Analytical Dynamics of Particles and rigid bodies*, Cambridge, University Press, Cambridge (1917).

[WS] S. Weinberg, *High energy behavior in quantum field theory,* Phys. Rev. **118** (1960), 838-849.

[26] B. M. Bolotovskii and V. L. Ginzburg, *The Vavilov-Cerenkov effect and the Doppler effect in the motion of sources with superluminal velocity in vacuum*, SOVPU **15**, 184-192 (1972).

[27] J. Singleton, A. Ardavan, H. Ardavan, J. Fopma, D. Halliday and W. Hayes *Experimental demonstration of emission from a superluminal polarization current, a new class of solid-state source for MHz-THz and beyond*, IEEE Digest **04EX857**, 591-592 (2004).

[28] B. M. Bolotovskii and A. V. Serov, *Radiation of superluminal sources in empty space*, Phys. Usp. **48** 903-915 (2005).

[29] A. V. Bessarab, A. A. Gorbunov, S. P. Martynenko and N. A. Prudkoy, *Faster-than-light EMP source initiated by short X-ray pulse of laser plasma*, IEEE Trans. Plasma Sci. **32**, 1400-1403 (2004).

HADRONIC JOURNAL 41, 305 - 333 (2018)
DOI 10.29083/HJ.41.04.2018

COMPUTATIONAL ATOMIC PHYSICS FOR THE FUTURE: MODULAR REALIZATION OF ATOMIC CONSTITUTION AND PERIODIC SYSTEM

Erik Trell
Faculty of Health Sciences
Linköping University
581 83 Linköping, Sweden
erick.trell@liu.se, erik.trell@gmail.com

Received January 14, 2019

Abstract

A computational approach to atomic physics modeling according to a recent initiative to "embolden astrophysical discovery by computer" adopts in direct structural geometry realization a fine-grained Lego brick organization system with coarse-grained Duplo expansion to animate the periodic table of the elements congenial to Mendeleev's original conception of its Sanskrit grammatical organization as well as the classically reconcilable lifting of quantum mechanics in Santilli's iso-, geno- and hypermathemathics.

Copyright © 2018 by Hadronic Press, Inc., Palm Harbor, FL 34684, USA

1. Introduction

A recent authoritative *Science* Perspective on "computer-mediated discovery in astrophysics" concluded that "antiquated code that is only intelligible to scientists who were involved in writing it is holding up scientific discovery in the field".[1] This could with equal reason be applied to the antipodal, atomic physics end of the range, where the "Copenhagen Inter-pretation's...sole lens of...the loose set of assumptions Niels Bohr and his colleagues developed to make sense of the strange quantum phenomena they discovered in the 1920s and 1930s...transformed into a pervasive censorship that stifled any opposition"[2] for nearly a century. Therefore, to continue the allusion, "a bold initiative is needed to modernize atomic physics code and make it transparent and useful beyond a small group of scientists"[1], whose "exclusionary rights may affect research"[3] and progress negatively in many ways.[1] Not only do the currently assigned atomic physics bits and pieces and their *sui generis* performance make the formulation of coherent computer systems difficult, but the structure of those that exist "is characterized by developments during the 'software crisis' of 1965 to 1985, when software was written as a long list of instructions without formal structure. The relative simplicity of these 'dinosource' codes facilitates their survival but frustrates further development".[1] What has been found needed "to embolden astrophysical discovery by computer" in the large scale and hence also in the contiguous microcosm reaches is a "modular approach" rewritten from actual structural observations and establishing an instant reciprocity between reality and the computer animation of it, in which read-in an read-out are as close to identical as possible, and whose "introduction...will eventually lead to more stable software, fewer bugs, and improved validation, verification and quantification of the results".[1] Continuing the quotations, "One potential analog for a modular, astrophysical software system is provided by LEGO bricks, which have a general interface and abstract fine-grained structure that enable endless permutations...For general programming, however, ...a more coarse-grained structure could allow collections of fundamental elements to form part of a larger structure...The resulting DUPLO blocks reduce graininess while mediating and stimulating experimentation. In terms of software, they would be equivalent to self-contained objects with a common interface structure, which enables inter-object operations".[Ib.]

At face value; how splendidly this pertains to the periodic table of atomic physics as well, and to Mendeleev's original conception of its two-dimensional Sanskrit language-of-Nature pages appearing on the screen like everything else

to continue their earthly world-line along the third dimension alone.[4-7] In the mathematical field, this essential kind of self-contained modular system with a common interface structure has from the ground of Lie-admissible algebra[8] been totally *de novo* realized by the iso-, geno- and hypermathematics of Ruggero Maria Santilli[4,8-11] where, crudely summarized, the virtual Lego bricks are the respective n-dimensional iso-, geno- and hypernumbers which hold the "fine-grained design" of the endless permutations of different "fundamental operations" which may be implemented in them, and which may then be executed as the equations of themselves or the "resulting Duplo blocks"[1] preserving the axioms of Mathematics to yield, inter alia, reconciliating classical solutions to Quantum Mechanics at the elementary particle and atomic level.

The subject of the present report is a corresponding direct structural 'isogeometry' building kit of computer-aggregated fine-grained Lego and coarse-grained Duplo analog modules which combine into extensive and exact reproduction of atomic constitution and the periodic table as part of an essential data set of infinitesimal mathematic physics material construction.

2. Methods and Results

The *Wellenpaket* concept was devised by Erwin Schrödinger in 1926 to encapsulate the solutions to his wave equation, relating to elementary particles and in especial the electron and its atomic orbits.[12,13] It can thus be said to be a kind of Lego bit aiming to build up space orderly and was for that reason immediately opposed by the pundits of the Copenhagen school. In especial Werner Heisenberg magisterially criticized what he described as its "narrow classical formulation of a real and casual description of objective processes in space and time", because "the wave function expresses a necessary and fundamental wave-particle duality...the inner workings of atomic and subatomic processes are necessarily and essentially inaccessible to direct observation, because the act of observing them would greatly affect them", and the "character of quantum mechanics is very tightly bound to the formal circumstance that its mathematical framework of wavefunctions operates in multi-dimensional configuration space, not in ordinary space".[14] Today, however, there is widespread acceptance and application of its basic idea of a differential quantum walled in by the adjacent real spatial fabric which convoys the consecutive stowing of the so hybridized wavepacket into the geometry of its field like in organic chemistry in order to "avoid kinetic trapping...chaperons encapsulate guest proteins...to help them fold".[15]

When here the infinitesimal structure of the elementary particle spectroscopy is resolved in the SU(3) and subgroups Lie algebras[16,17], and more particularly their normal geometric SO(n) automorphisms, it is in the classical basic framework of the ordinary Euclidean universe fulfilled by the real solid state configuration space $R^3 \times SO(3)^6$, where the ground R^3 frame is the Cartesian coordinate system and SO(3) governs the commensurable elements and events therein. Three parameters from R^3 and three from SO(3) with together five degrees of freedom (since one horizontal axis commutates) thus interweave a physical wave-packet compound as a unit interval of a coherent structural worldline where the R^3 frame naturally appears as a unit cube, or 'CuBit'. Physically projecting the analytical neighborhood of the respective Lie algebra it may further modulate itself into isomorphic parallelepiped and/or relativistically or otherwise skewed layout, which actually blueprints the entire elementary particle spectroscopy.[5,18-28] And also in a static block embodiment it has interesting, in especial mathematical uses as a whole-number counting frame bead with straightforward abacus bearings and solutions to Fermat's last theorem by cumulatively tessellating the infinite Diophantine Equation Universe both according to classical Sumerian building principles as adopted and adapted by Euclid[5,21,23,24], and in a likewise infinitely ascending Pascal binominal expansion order.[21,25]

The SO(3) moiety has a double identity as its in ground state spherical eigenelement as well as algorithm of its own volume-preserving spheroidal, that is, in QCD sense, gauge- and symmetry-invariant transactions and transformations, which as mentioned enable an exact and exhaustive reproduction of the entire elementary particle spectroscopy including charge, channels, states, angular momenta and masses.[5,18-28] The present report focuses on the joint $R^3 \times SO(3)$ geodesics according to the full differential equation scope of the original Lie algebras, which generally iterate their universal partial derivative "geodetic curves of length equaling zero" to "transform two spaces into each other", and more specifically in the SU(3) case how the "Plücker line geometry can be transferred into a sphere geometry" by trigonometrically "transforming space r´s straight lines into space R's...spheres' rectilinear generatrices" (= infinitesimal generators), where "x, y, z are perceived as parameters and...dx, dy, dz as direction cosines".[16,17] The so absolutely sharp transition of the respective geometries' infinitesimal generators can thus be effectuated by the corresponding root space diagrams of their commutation relations. In SU(3) this is A_2, which is doubled to switch from the complex number field to the ordinary three-dimensional structure of R^3. As shown in

Figure 1, it is accomplished by a real geometry coset decomposition of SU(3], that interlinks to the infinitesimal generator root vector space of the sphere directly spanned by the duplicated A_2 diagram, whose neutral isospin vectors coincide with the Cartesian x and z axes but whose charged *t* isospin axes set up a hexagonal lattice with unit side continuing in the surrounding as space-filling regular tetra- and octahedrons. It is a template for both inward nucleon[26,27], surface muon[17-27] and external baryon and meson[Ib.] transformations, whereas the electron (and positron) geodesics are generated by a coherent continuation of the charged *t* isospin vectors as will be focused on in the following.

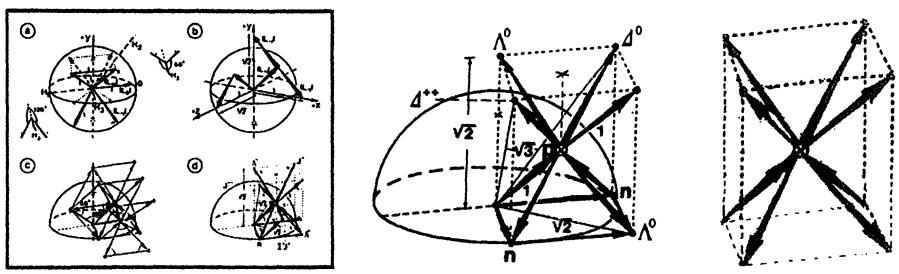
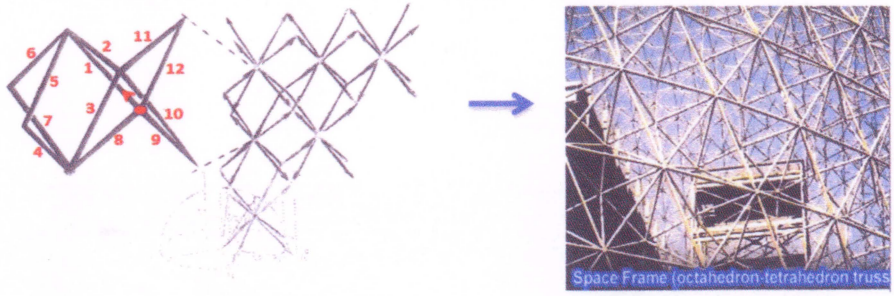


Figure 1. a-d) Duplicated A_2 diagram knits a hexagonal SO(3) infinitesimal generator lattice in and out of the unit sphere, e,f) globally distributed and linking in space-filling parallelepiped R^3 geometry-aligned chaperon enclosures. Note in Figure 1e the root vector projection of the major semiaxes of the volume-preserving Λ^0 and $\Delta^{0,++}$ ellipsoidal transformations and that one charged SO(3) root vector, p = proton, and two neutral R^3, n = neutron space vectors are central and thus in pivotal position to the rest of the lattice.

Figure 2 then summarizes how the charged *t* isospin root vectors can be linked to a coherent triple helix in a continuous cloverleaf 'singlet coil' sequence of 12 unit steps – equally many as the edges of the cube – into the only other space-filling regular solid convolution, namely, a complex of one octahedron and two tetrahedrons (Figure 2a). It is a real phase transition which in iteration (Figure 2b) forms an important nanotechnology structure, i.e. an ordinary space frame, alias octahedron-tetrahedron, or octet truss whose modular building blocks and their assembly can thus be realized from the ground of material organization.[4,5,29] It is what Buckminster Fuller called "an isotropic vector matrix (IVM) field...with everywhere-the-same energy

conditions".[29] Instantly spanned as a simultaneous filigree all over the field[lb.], it will crystallize like when ice freezes from multiple infinitesimal origins as an at once homogenously distributed infinite universal inflation.[5,27,]



a b

Figure 2. a) Linking of coherent charged *t* isospin root vectors, forming between them an outwards connected lattice, which from a chosen outset, here at the octahedron equator, b) iterates to an octet truss space frame of isotropic vector matrix constitution.

The IVM is three-dimensionally spacefilling *in toto* by itself but how to "adopt the correct topology and avoid kinetic trapping"[12] when realizing this from isotropically distributed infinitesimal sites requires chaperoning the continuous SO(3) wave function out of each of them by a globally close-packing cumulative brick-laying of its to that end suitable parallelepiped R^3 Euclidean space 'exoskeleton' cage as outlined in Figure 3.

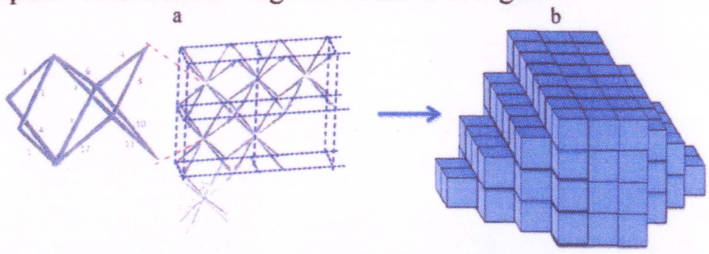
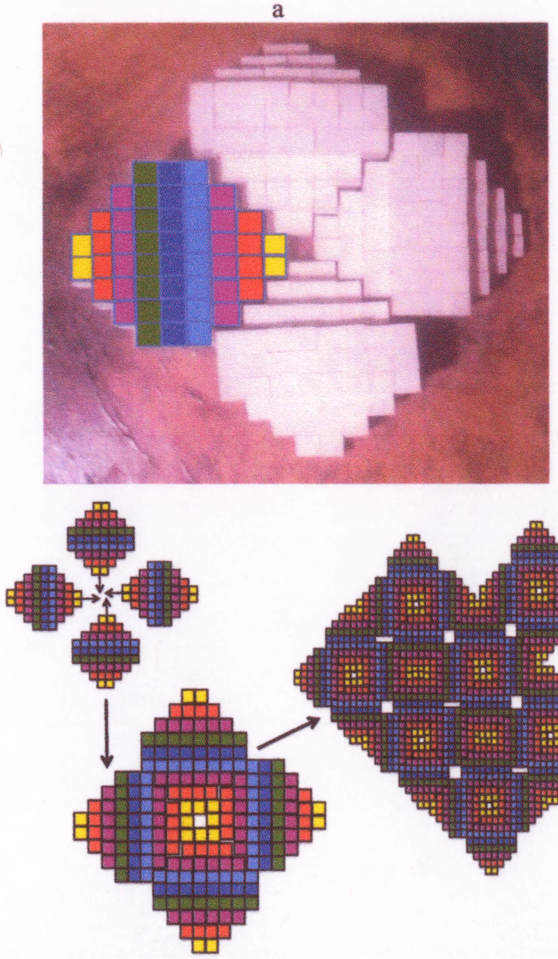


Figure 3. a) 12-step space frame SO(3) singlet coils ("grains of nature")[29] are mirror-distributed in vertically and horizontally coherent parallelepiped wave packet cages **b)** which can be successively stockpiled in a 2+8+18+32+32+32+18+8+2 = 152-step coherent chaperon sequence into a trapezoid bottom plate module of palindromic Bohr orbital distribution whose inner continuous 152×12-step SO(3) wave filament outlines the electron - or obverse positron.

Figure 4 summarizes how these modules can further pave the spatial ground by joining together either with a closed center (not shown) or, as shown, leaving a central unit cubic gap which, in turn, provides a pivot in the further close-packing. It forms a bottom plate with flat base and to complement it,

a



b

Figure 4. a) Photo and b) graph of four modules gathered to rhombic bottom plate with central gap and in aggregation leaving unit corner defects. *Colors refer to the noble gases*

as shown in Figure 5, with a flat roof enabling vertical piling, a reciprocal complement is needed and can be mobilized out of space by nilpotency.[30]

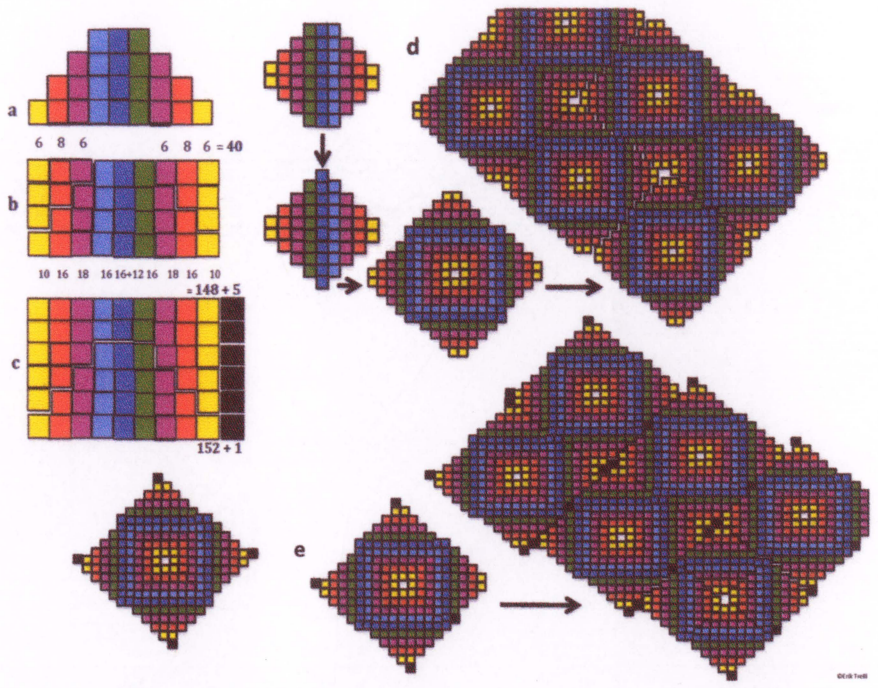


Figure 5. a-c) Side view of successive packing of compound module to flat roof, enabling dense vertical piling. d) Top view of formation of compound module with 152 cuBits in both lid and ground part and showing that the central hub gap is transferred in the center, and that a static space-filling packing between neighbors is feasible but in practice means obliteration. e) The compound module (Figure 5c) introduces an extra step so that the inertial relation between the inner SO(3) wave function and its R^3 spatial chaperon is $(152+1)\times 12 = 1836$ which is exactly the electron/proton mass ratio. However, it cannot be packed in the horizontal plane since this is already full.

This can be performed in one version with an open central unit hub and one with closed center and thus, like the Einstein-Bose Condensation state, at a standstill.[28]

One could trace the initial nucleogenetic events to the formation of Helium as in Figure 6 below. The general hypothesis is that the initial compound modules in the primordial plasma and stages after can continue to stack

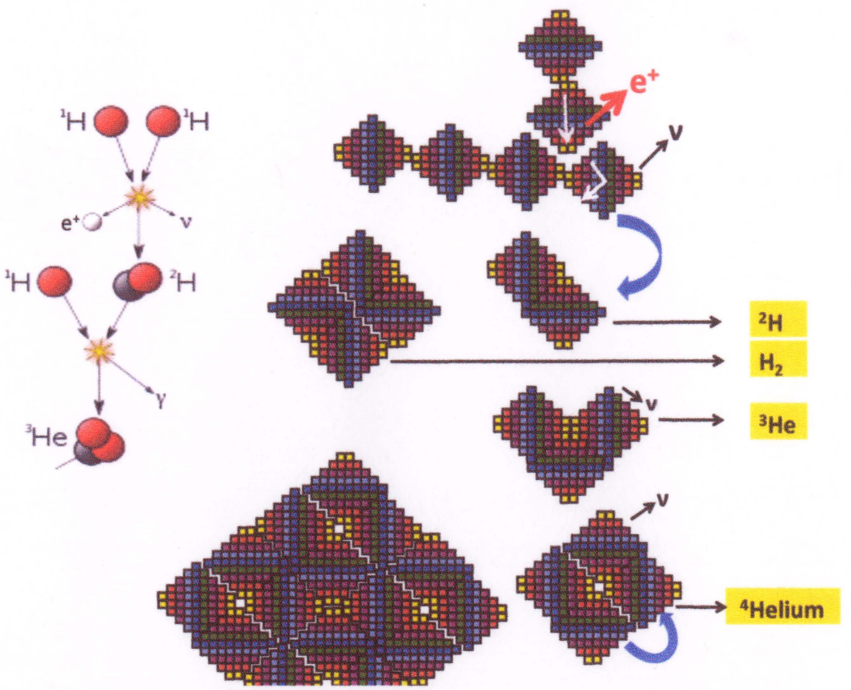


Figure 6. One variety of initial nucleogenetic formation of Hydrogen isotopes and of Helium. Note that the fusing of two primordial hydrogen ion modules forms a two-module that can be identified as ^{2}H and that a ^{3}H is feasible, too

in its own pattern in successive generations potentially reaching enormous size. But with that inflation there will tend to be ripples and neighbor confrontations and clashes building up to increasing perturbations finally reaching to magnitudes of collapsing stars and supernovae so that the aggregates start to dismantle in correspondence to the strength of the condensation and when at last back in the first generation the primary modules that still survive are extruded as a coating onto the transversal plane aiming at an identical space-filling sequential arrangement as the same number of the outset R^3

parallelepipeds (Figure 3a) would assume were they flattened out from the front and inwards of the bottom anvil plate of the original wavepacket. In the version shown in Figure 5 there is a transferred hub region, but no room for an extra step so it would be a static, speculatively deep-frozen Bose-Einstein Condensate type of event. However, there is an alternative mode in which "according to the modern conception of the Universe's evolution, at an early stage of its existence there was a vacuum phase transition leading to the vacuum torsion described by the Higg's field" and by which "the Universe has become gyrotropic".[31] This is schematically outlined in Figure 7 where the impact and effect of the compression between two bottom-plate modules is to shear off their margins in the form of a backwards electron - that is, positron - and joining the inner halves as an electron in diagonally symmetric bent form.

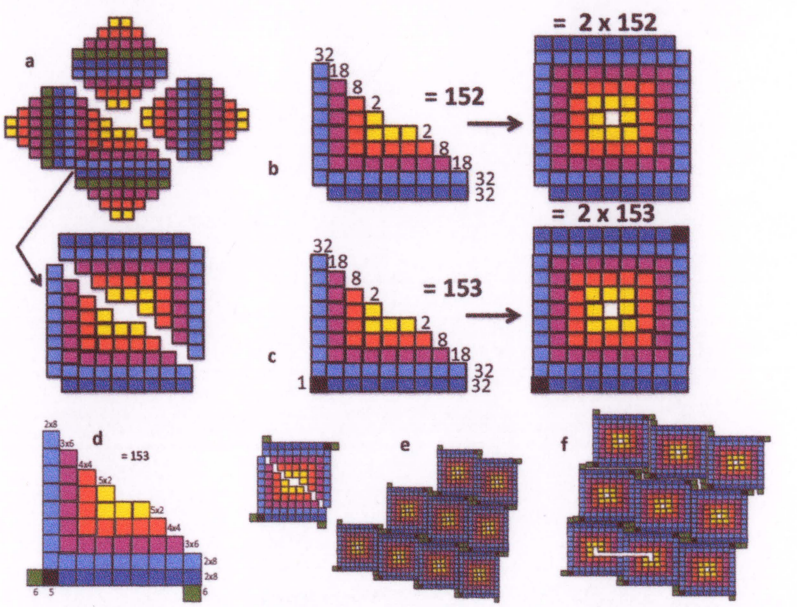
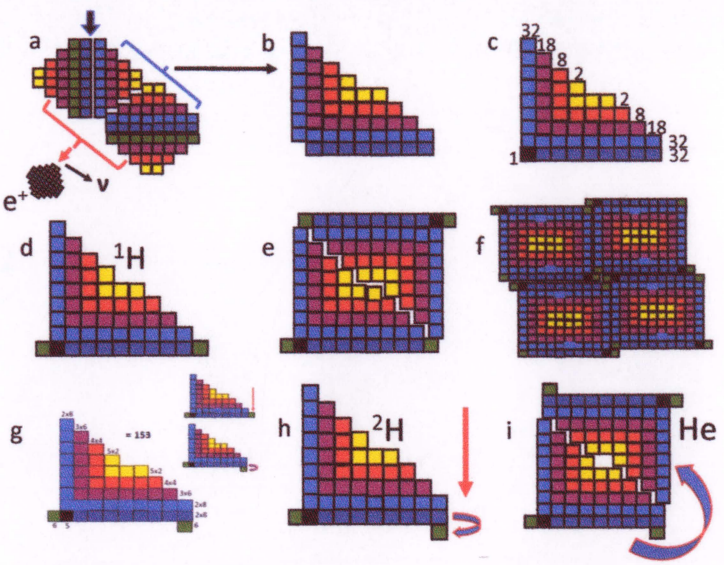


Figure 7. a) The 152-bit bottom plate can also be formed by two adjacent corner halves of the bottom plate module, and b) with the diagonal moiety forms a cross-section of near-rectangular shape and can be tiled via the corners. c) When an extra step to 153 modules is made, the cross-section is fully rectangular and instantly tileable. d) Filling the lid part means adding 5 bricks to the extra step plus two columns of 6 each, and corresponding contour.

So far, this is a theoretical estimation of initial conditions and will be kept in that speculative state, seeing where the astonishingly simple building elements one may already discern might lead and how they will hold in comparison with the actual spectroscopy. Extrapolated to the Big Bang premise it corresponds to the first three stages of this, namely, the initial provision within the first second of all the vector elements to be processed in the entire structural evolution, and in the ensuing few seconds the condensation of Hydrogen and Helium (Figures 7 and 8) as the main substrate of the stellar nucleosynthesis of the other atoms billions of years later. It is a two-step forging of the ^{1}H to ^{2}H to He chain which



© Erik Trell

Figure 8. a) An outcome of an eccentric interception of two primordial bottom plates is a twisted split into a ricocheting peripheral positron halve and b) a residual 90^{O} angled core module which has a free corner gap offering c) an extra return or entrance step of the wave-packing sequence, adding to 153. d) The cap adds 5 corner and 2x6 outer columns to the rim of the combined module in an at the ground stage flat outline shaping the ^{1}H, Protium variety of Hydrogen which e,f) combines with others of the same kind in a sideways stashing order. g,h) When Protium is compressed perpendicular to its rim one terminal column of this may be flipped and so poised to climb, and i) Helium is formed by a diagonal accretion mechanism.

is in fact even finer as not illustrated here but can be outlined in colloquial Big Bang terms and conveyance turned bottom-up: not one sudden singular central top-down detonation in nowhere from nowhere but an all-over distributed phase transition of an ubiquitous state. The opening leap over a single angle in an unimaginably brief moment at the dispersed origins everywhere at once sets out the rhombic primordial plasma modules of Figures 4-6 in the underlying R^3 space coordination, but since they cannot find place for the extra step when advancing they intercept sideways and duplicate tangentially into the orthogonally inclined Protium ions (Figures 7 and 8 a-d). Along the standard x axis, these thus come in a left-handed and a right-handed alignment and when one of each of these tie up they smoothly embrace to the Protium molecule, continuing as inert Hydrogen gas (Figure 8e-f). But when they are in parallel polarization they cannot coexist so the adjoining one starts to peel off its charged electron lattice in reverse order, that is, as a positron as indicated in the upper left diagram of Figure 6. The R^3 chaperon template is thereby exposed in its physical lattice form as the neutron which likewise in the few seconds of the whole actual Big Bang nucleosynthesis emerges at this stage and which with a neutrino snap gets a unit corner pivot and in that shape can tumble on by itself or coalesce with the Protium module to Deuterium (Figure 8 g,h), which then can continue the chain to ^{4}He (Figure 8i). However, a neutron or a Protium can also straddle the now neutral Deuterium and, as in reality, too, in the first case generate ^{3}H and in the second ^{3}He. Thereby, beside some single Tritium and possibly Beryllium, the Big Bang nucleosynthesis era is concluded - within half a minute - delivering together with a variety of neutrino and photon concatenations of the straight unit length lattice vectors literally the whole primordial start-gas to billion-year wait for sufficiently energetic perturbations with itself for astrophysical/cosmogenic/experimental nucleosynthesis of the full periodic table.

It is the necessary and sufficient building kit to that end and will be used as such without much further comment in the further tessellation, in which ^{1}H can be identified as the SO(3) β brick with ½, Fermion spin, and Helium as the α $R^3 \times SO(3)$ wavepacket with unit, Boson spin. All following atoms can be assembled and disassembled by the successive concentric splicing/unsplicing of the β and α tiles and their aggregations in net Fermion or Boson spin steps as in reality and meaning that every noble gas (in principal state) is a Boson.

But the size of the atomic nuclei is in the elementary particle scale whereas the ready atoms are tenthousandfold larger. The solution is that the ground block assembly is automatically spacefilling and if also the silhouette of the

resulting aggregate is self-similarly spacefilling over the plane, too, the atomic diameter can be covered in a hierarchical order according to Figure 9.

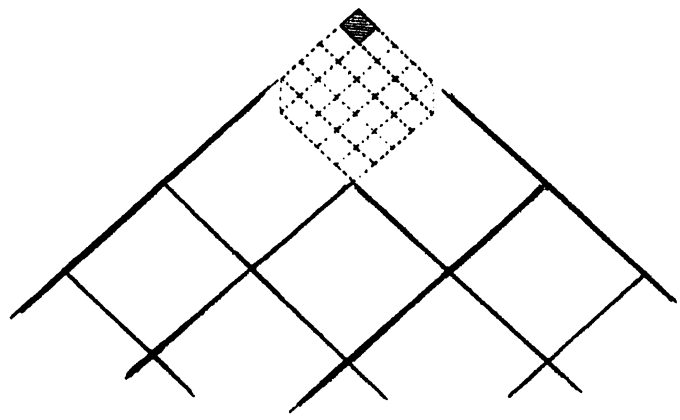


Figure 9. Horizontal plane diagram of first three periods of hierarchical expansion of a ground nucleogenetic state to full atomic cross-section area by cyclical iteration of its spacefilling outline.

This speckled distribution of the nucleus over the atom cross-section area is actually not against any theoretical or observational evidence, including Rutherford's famous gold foil experiment, when one considers also the interaction phase-shift between loci due to their consecutive actualization. And the two-dimensional inflation of the atom over the plane/brane is in effect another support of the sameness of Cosmos over and between its largest and smallest aspects and in consequence also astrophysics and atomic physics. For instance, a "black hole may look three-dimensional but it behaves as it were two-dimensional...The number of 'molecules' it is made up of must be proportional not to its volume but to its surface area."[32] This is referred to as "the holographic principle... because...it presents itself to us as a three-dimensional object" but "turns out to be an image produced by a two-dimensional sheet of film."[Ib] And "in string theory...fields...live on the surface", while vice versa "in M-theory...a special type of particle: a membrane shrunk to a point"[Ib.] is considered. The results and inferences here are therefore in line with the latest scientific findings and analyses of material constitution and behavior at the extreme, and also how an atom cluster looks

like in the high-resolution microscope it goes along with: as a cross-section of an electric or suspension bridge or nerve cable.

So, it should be ready to start the brick-laying. In Figure 10 against the background of a lateral projection of the original bottomplate module the positions of the Noble gases and their generation from there are indicated, and the clusters of α particles between them with the same cumulative arrangement are shown, determining the reproduction.

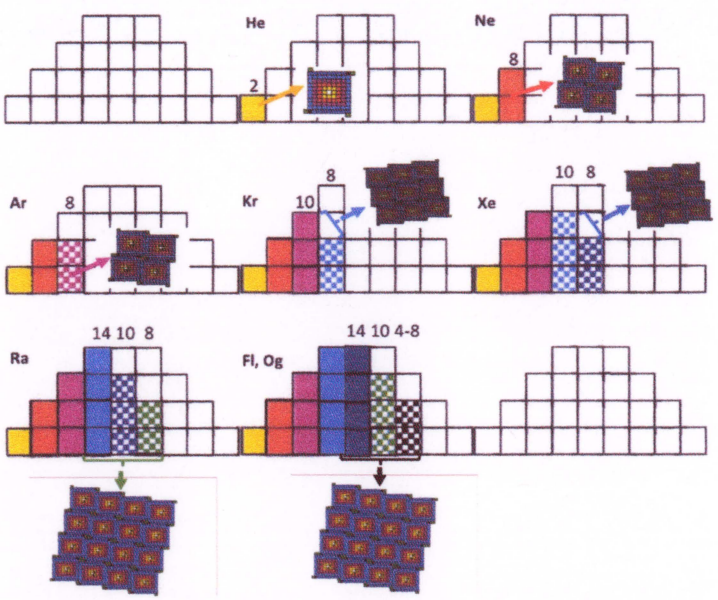
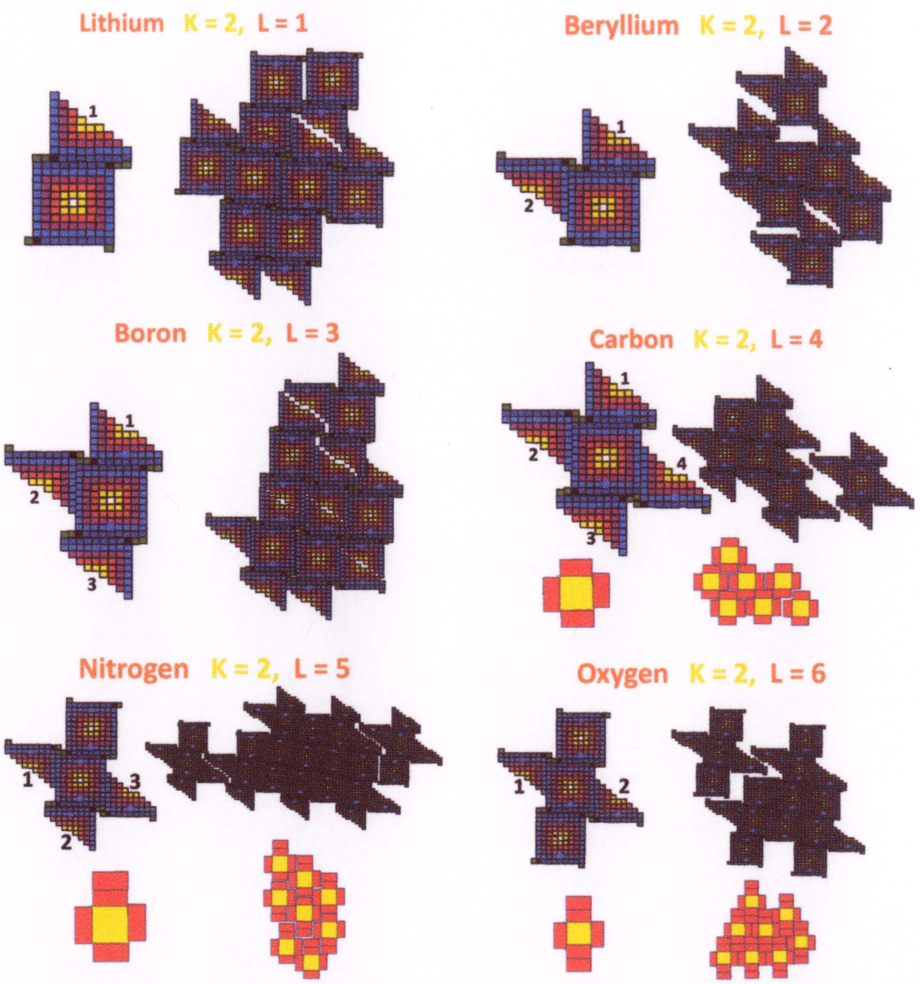


Figure 10. Lateral projection of noble gas extrusion from bottom module in same order as the singlet wave packets and terraces are arranged therein (dotted are internal layers). It is seen that the atomic periods, each terminated by a noble gas are filled obliquely like a conifer in squares of 1, 2, 3 and 4, and that there is spare room for a 16 $\alpha/32\beta$ period beyond Oganesson. Also the subshell organization is represented in the implement (not shown).

The elements of the K shell have already been shown (Figure 8 h,i) so now

the reproduction goes on with the L shell and their space-filling (Figure 11).



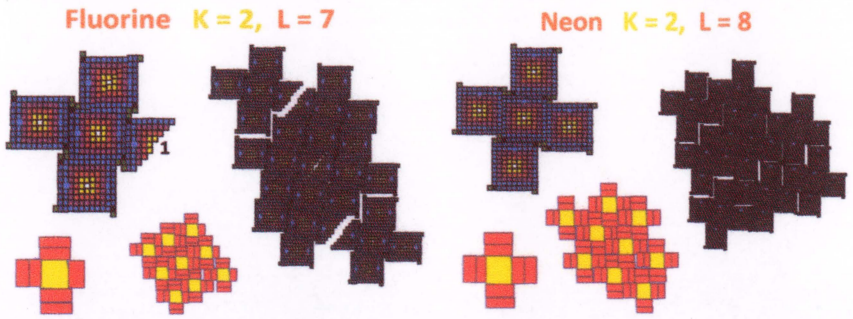
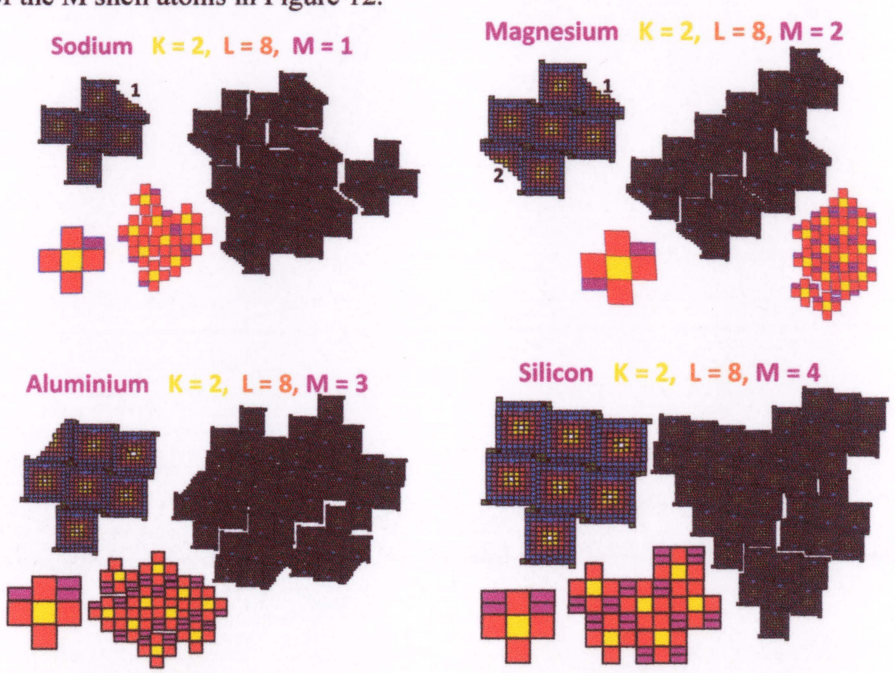


Figure 11. L shell atoms with oxidation states in spacefilling fine-grained Lego block tiling, from Carbon supplemented with Duplo simplification.

Already in the L shell other assemblies of the blocks, with different oxidation state, are feasible, e.g. in Carbon. This is further exemplified in some of the M shell atoms in Figure 12.



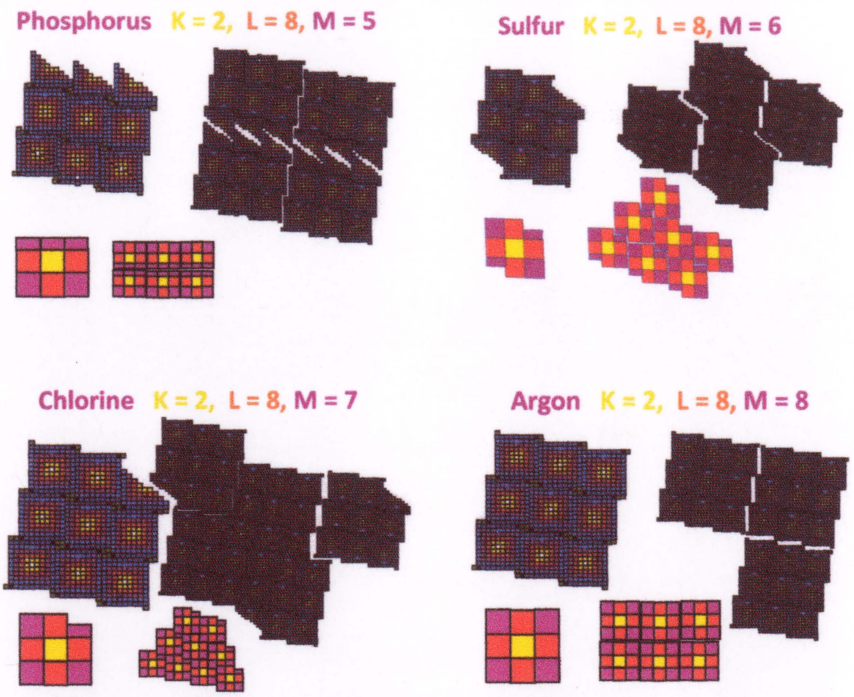


Figure 12. Examples of the atoms in the M shell. As in Figure 11.

One starts to discern the stochastic, i.e., random yet deterministic conditions at hand in which a widening range of isotopes occur with higher atom number because there are different ways of assembling the basic building blocks so that variable configurations with correspondingly varied oxidation states, i.e. number of peripheral β bricks result. But with increasing atom number another sine qua non of a universe made and filled exclusively by itself crops up, namely spacefilling, which is harder and harder to obtain the larger the constellation. One approach, after reaching Argon, would be to column-wise accumulate its motif sideward in two periods of 18, first reaching Krypton and finally Xenon (Figure 13a), and then continue row-wise in the perpendicular direction (Figure 13b) till in the fourth of them, and totally seventh, ending up at Flerovium and Oganesson. That gives a diagram with 18 columns and 7 rows

like the standard Periodic system and is totally possible to fill out

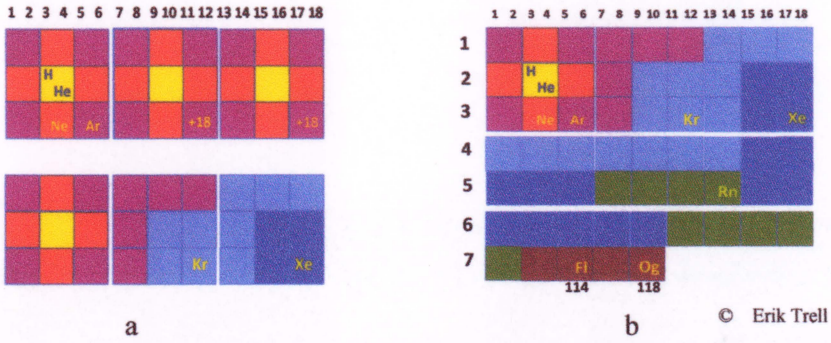


Figure 13. a) Edgeways loading of periodic table by *a* tiles, with noble gases up to Xenon. b) Continuing up to Oganesson, with room for heavier elements.

by coarse-grained Duplo tiles, here the *a* particle, and each state close-packing the plane by itself and its mirror-image. As further examined in Figure 14, even

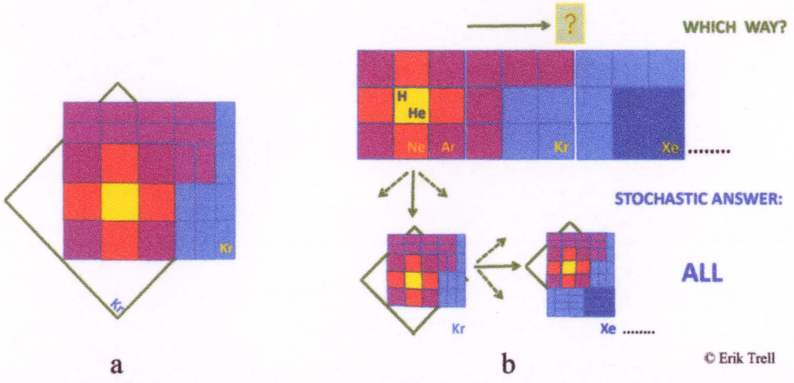
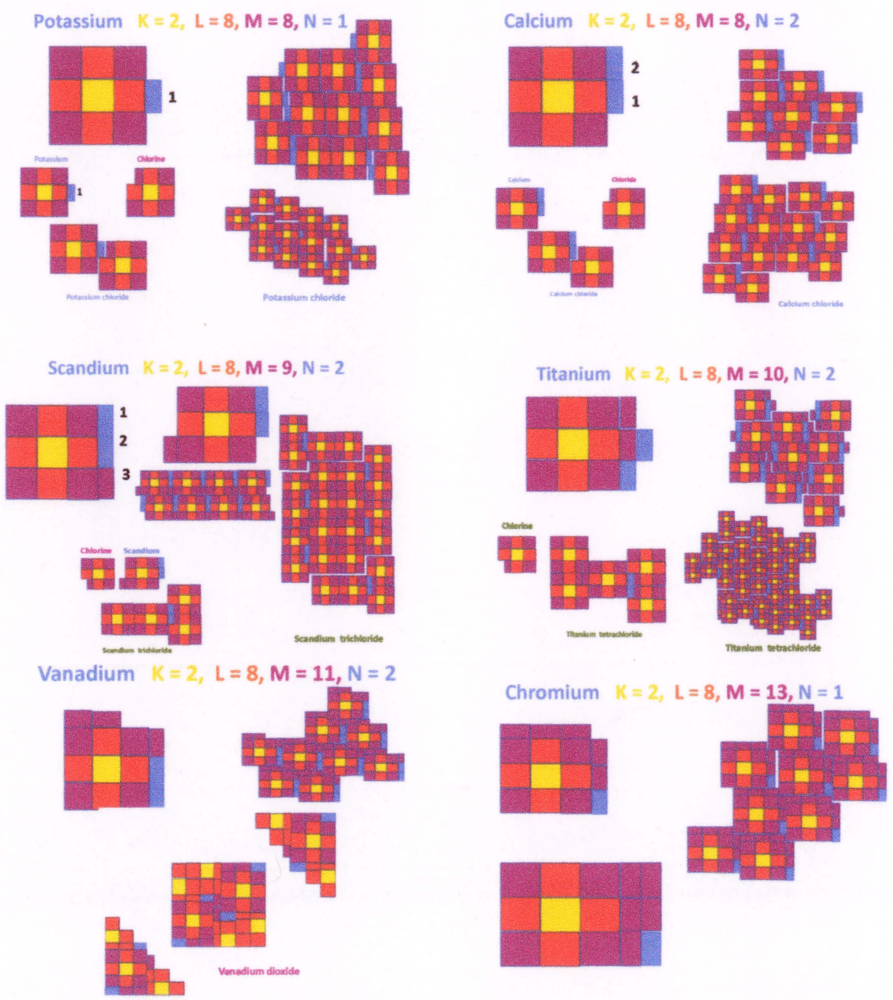


Figure 14. a) Unilateral loading of Periodic Table up to Krypton. b) Continuing from Krypton to Xenon by same consecutive laying of marginal bricks.

if it cannot be excluded that in an extremely rare instance this sequence may be followed through in all its subsequent steps it is against spatial symmetry as well as the arrangement of wavepackets in the module and the corresponding shell distribution in reality, all of which pointing at a bilateral centrifugal expansion order.

To illuminate the principles, examples of the first nine elements in the N period are sketched by Duplo tiling in Figure 15. It is seen that the marginal β particles may be single, each offering a positive oxygenation site but by different placement may cover each other to neutral a particles or even, as in Manganese, by the combination of β particles (here 6) to a blocks (3), walling



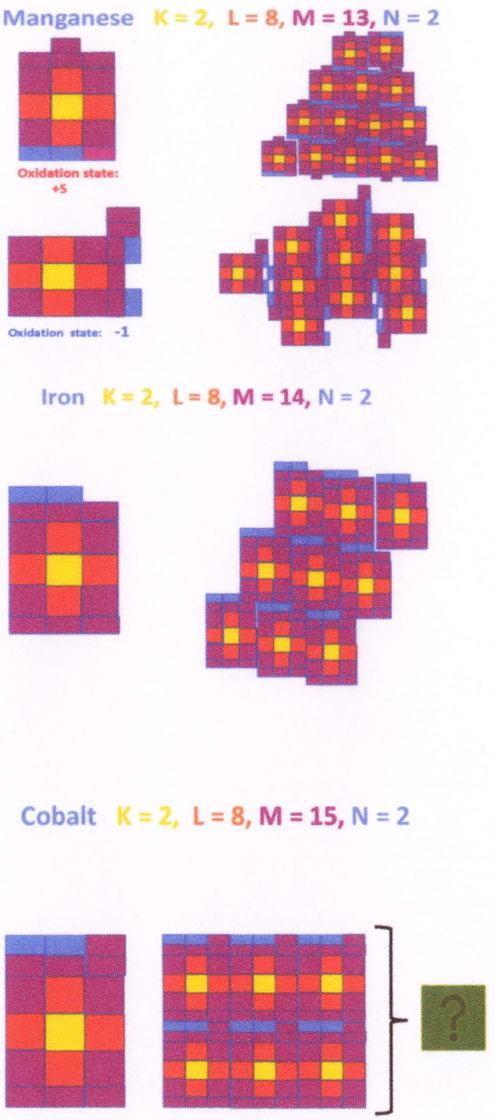
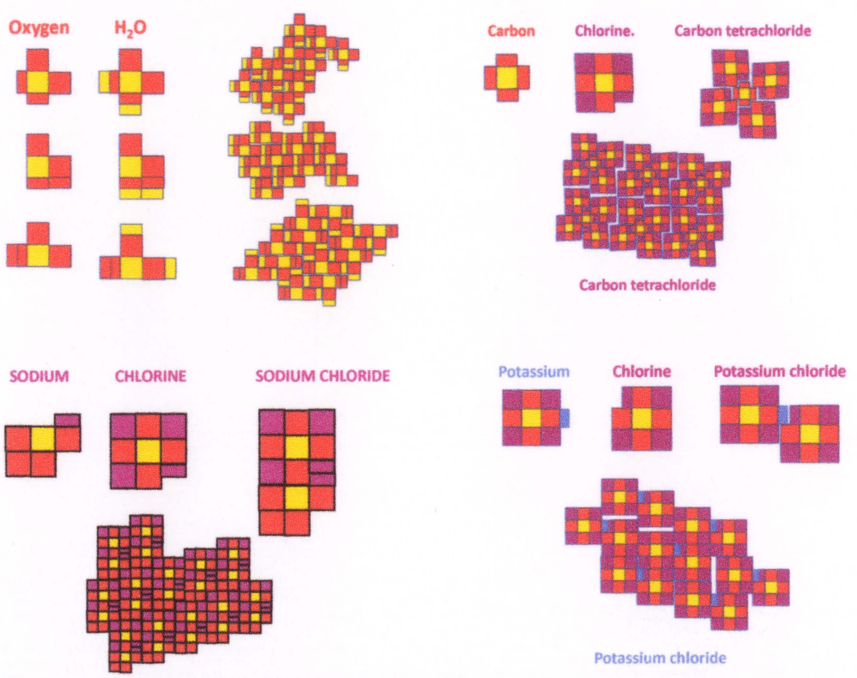
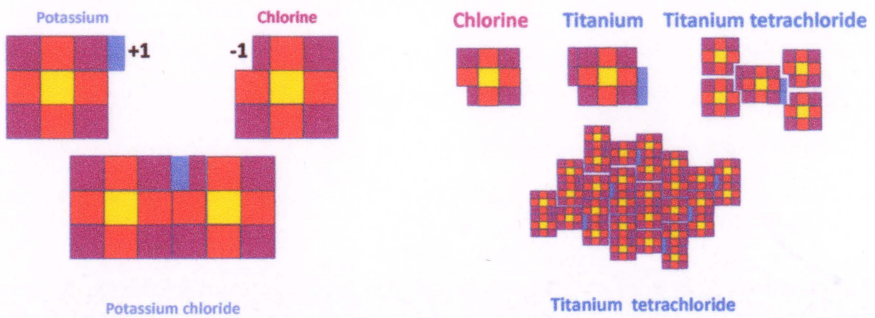


Figure 15. Duplo-type tiling of first nine elements in the N period.

in a gap with negative oxygenation state. The ability to replicate space-filling chemical compounds is a vital reality testing of the whole model, and in the case of Hydrogen and other simple bonds they are clear without further comments from practically all previous figures. In Figure 16 more examples are given of some larger molecules and their space-filling. It is to be noted that there are no drawings of the bonds because the atoms connect directly and the apparent impression of interspaces is that in every interaction moment only one infinitesimal point area of the larger surface is engaged, which is also the case in atomic spectroscopy and gives the individual signature of each element and its isotopes.





© Erik Trell

Figure 16. Some chemical compounds and their space-filling.

So, it would be possible to follow the unilateral track of Figure 14, too, to reach all the elements. However, it again violates the fundamental parity both of the module organization and the orbital distribution in the spectrum of atom states as they appear in the actual periodical system and notably so from the N shell where the first two members start with one and two electrons, respectively, in it, and the ensuing ten atoms as a rule retain these and then, as should be possible to partially infer from Figure 10, successively fill the preceding M layer by the sides to finally in the ensuing six states close the initiated M rim, thus completing their period by Krypton - after which the next stage proceeds by opening up the O shell with one and two electrons, then ten in the M shell and six back to O yielding Xenon…and repeating that procedure in the swelling P to Radon and Q to Oganesson cycles; and conjecturally further (Figures 10 and 13).

This is apparently how Nature must do it in order to transfer the module's stacking pattern to a flat distribution under the condition of both local and global fulfilment and integrability in the expansion. Expressed in a teleological way: When a number of electron modules are fused together by sufficient power to do so; what is needed to enable their aggregate to pave the plane? This will require means for the areal patching so that corners and marginal defects can be filled making the tile spacefilling or otherwise redressed for neighbour interactions. The methods and principles developed in the foregoing are adequate and applicable to that end, so that the same Duplo type of coarse-grained tiling principles can be applied when amending the charting to cover

the whole width and variability of the periodic system including the vast isotope spectrum. For that, the single-layer neutron and Protium β bricks also generated in the Big Bang nucleosynthesis are employed according to availability in the fusion environment. In general, neutron inputs, only affecting size and shape will be more stable than those of Protium due to the charge influences of this so that a β decay under positron emission would be the natural next strep of a Protium excess. This is under closer study, however, so will not be described in further detail here. But to exemplify the mechanism, figure 17 shows a neutron insertion in an isotope of Scandium, which might

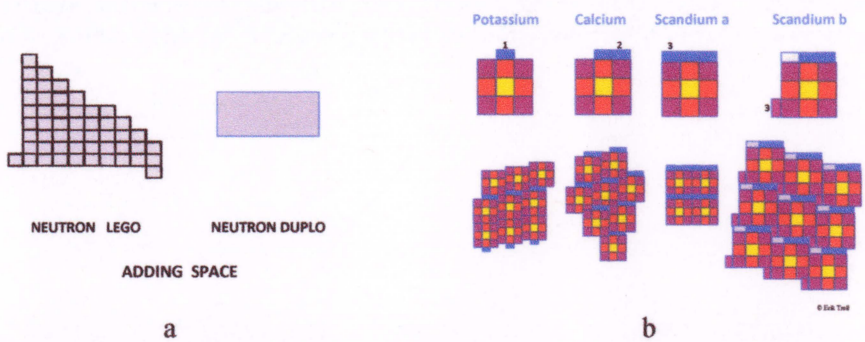


Figure 17. Introducing spatial patching by neutron excess. a) The neutron depicted here in an equatorial plane Lego tiling is the bare R^3 chaperon/exoskeleton of a Deuterium module. In the nucleogenetic turmoil many $R^3 \times SO(3)$ wawepackets are squeezed so that the frame and the IVM moieties are separated. This is actually observed in the isotope spectrum where both electromagnetically inert neutrons and charged proton/electron complexes with just a little lower unit isovector content and inertia than in the external neutron abound. b) Atom precipitates are oriented towards shapes that are as much as possible square and globally packable or, as suggested here in Scandium, favourable as underpinning for successors, and when they cannot cut a corner or fill a gap to that end, a neutron will provide the spatial bridge, here rendered in colour-less grey in the Duplo rectangular brick simplification.

seem to be a bit late, because there is a neutron excess also in many lower states. But it is not obligate and observations on Argon support that when here reconstructing the nascent, stellar nucleosynthesis of the elements, the N series is the stage where neutron excess gets systematic. As reproduced in Figure 12,

Argon there has the mass number 18 + 18 = 36. But nearly all of the Argon in the Earth's atmosphere is ^{40}Argon, derived from the decay of ^{40}Potassium in the Earth's crust while in the universe, ^{36}Argon is by far the most common isotope, as it is the most easily produced by stellar nucleosynthesis. Therefore, "pure" Argon sets the endstage of the M shell at neutron excess = 0, and leaves the differences between the reproductions here and the observations at a calibration matter. And this is the case in almost all stellar/cosmogenic/artificial nucleosynthesis cycles that they take place in multiples of alpha particles with beta addition or subtraction in the following decay modes to the isotopes represented in the periodic table and accounting for much of the very large quantitative variations found in this. Much work remains at this stage but is should be clear that a powerful iso-natural approach has been found to be expounded in the future.

3. Discussion

The present report stops here because such revision and expansion are still under way. However, applying modern computational and iso-mathematical methods to this field has been most promising. In a structural iso-geometrical sense a direct "surface growth mechanism of crystallization" has been emulated, as has been revealed at Silicate-1 ion subnanometer-scale resolution by in situ atomic force microscopy imaging[33], and revealed "step heights, terrace widths, and other surface features" accumulating in layers horizontally and upwards under "realistic growth conditions" [34] with a central diagonal orientation in an ordinary Euclidean space frame strikingly akin to the $R^3 \times SO(3)$ solid state symmetry. No rotation is involved but an accretion of linear precursor stages, which is also in correspondence with the application of Lie's partial derivative "straight line whose length equals zero"[16,17] as the sole element of the real structural mold. In that respect it is thus different from the standard model which builds upon rotation and transmutation of quarks under the SU(3) rules whilst in Lie's original work on the continuous groups and algebras he noted that "in that we restrict ourselves to the linear transformations of r, we find between the corresponding transformations of R: all movements (translation movement, rotation-movement, and the helicoidal movement), semblability transformations, transformation by reciprocal radii, parallel transformations...etc".[lb.] Then, instead of quarks, the three hexagonal space axes, of which one commutates with the orthogonal in the horizontal plane (Figure 2a) serve as the fabric of the system where the SU(3) and subgroups operations are otherwise commensurate.

One thus, from time immemorial, comes back to the future. There are many parallels with ancient Vedic and Mandala cosmographies and with periodic Arabic tiling[35,36] but the strongest identity is the cube-octagon and cube-hexagon hyperspace semiology of the African Igbo-Ukwu culture as revived and updated current records by Alexander Animalu and his group.[5-7,28,37-40] It is no chance coincidence - and showing the kinship - that he is also one of the strongest contributors to the iso-mathematical science.[9] All is on the line, in close contact, and thereby solving the dilemma of the chemical bond, too; Not a substance-less tentacle yet snaring the point atom in its intersections, but tight on in the unit contour. A strong case can therefore be made for the infinitesimal straight line as the sufficient and necessary ground element of physical substance. Aristotle originally postulated that "whatever possesses dimensionality is body", which dictum Cartesius articulated as "the extension in length, width, and depth which constitutes the space occupied by a body, is exactly the same as that which constitutes the body...consequently, there cannot exist a space separate from body, since all spatial extension simply is body".[41] This edict entails the complete filling of a physical space as well as a mathematical field by extension's own unique eigenvector element which Lie, who in the foreword of his thesis declared that it "stands in an intimate dependence on philosophical reflections upon the nature of Cartesian geometry", found to be the infinitesimal straight line[16,17]; both as a mechanistic matter of fact and in a deeper exegesis as the categorical contrast to nothing at all.[4-6,23,28]

Time has come to consider again, in the light of the true Lie algebras the visionary ideas echoing through the ages of the universally generating phase transition between straight and round and the implications of it as a collective gravitational force and fall between the inner surface of the cube and the outer surface of the sphere, beyond which no further contraction is possible and therefore remaining as the universally distributed dark mass with its compulsory dark energy drag and irreducible infinitesimal embodiment as the proton (Figure 1e)[5,18-28] in which further transformations must therefore be both volume- and symmetry-preserving and so enabling an exact and extensive geometrical reproduction of the elementary particle spectroscopy [Ib.] as well as delving behind the surface into the "hidden valley"[42] of "hot nuclear matter"[43], too, and finding the events and "echoes"[Ib.] of *charm* and *bottom*, the tau , the gauge vector bosons, charmonium and other resonances there.[22,23,26,27]

And it seems that the entire menagerie and tool kit of the displayed structural vector elements of the atomic nucleogenesis were handed out already

in the first seconds of the Big Bang when the phase transition concretely kicked off. The straight line sides of the cubical R^3 and the hexagonal SO(3) lattice would come out individually as the respective neutrino, each of infinite length and thus zero mass but in different inclinations of its path. And longer sequences of the SO(3) lattice would get zig-zag sinusoidal shape as photons with trajectories of likewise infinite length and zero mass; and the SO(3) lattice itself is consistent with the electron's double identity as "wave function or transition matrix element"[44], and protons and neutrons in their one-dimensional vector form (Figure 1e) were conceivably produced in the first seconds, too. In fact it is a Grassmann-Clifford linear algebra set whose operations fulfill the stated rules and axioms therein[5] and hence also those of iso-. geno- and hypermathematics.

At the same time it defines a modernized atomic physics code for a modular software system in analogy with "LEGO bricks, which have a general interface and abstract fine-grained structure that enable endless permutations", as well as "for general programming... more coarse-grained...DUPLO blocks reducing graininess while mediating and stimulating experimentation...equivalent to self-contained objects with a common interface structure, which enables inter-object operations".[1] It is interesting that ends and means in this way meet so that the output is simultaneously the input in the outlines of a computational atomic physics for the future.

4. Acknowledgements

I was kindly asked by my friends and mentors, Ruggero and Carla, to give a personal presentation and here it is. But of course it is much their work, too, both conceptually and in spirit and amendment; with ever so generous and helpful discussions and advice and new ideas and suggestions and inspiration in countless meetings and contacts and visits over the years. And it is also clear that this paper is a co-work with Alexander Animalu and colleagues and friends in his team, who brought me to the heart of the matter in a primordial cosmography standing the test of time so that today the patterns come back to the future even in the ultra-modern string and related theories' strive to surface on the Earth in a recognizable structural packing. And many others, Peter Rowlands, Stein Johansen, Mahim and Avishek Adhikari....have shared and instilled so much knowledge and wisdom and support, without which the present paper would not have been written.

5. References

[1] Portegies Zwart S 2018 Computational astrophysics for the future. *Science* **36** 979-980

[2] Frappier M 2018 Questioning Quantum Mechanics *Science* **359** 1474

[3] Contreras J L 2018 The anticommons at 20: Concerns for research continue *Science* **361** 335-337

[4] Trell E 2014 Lie, Santilli, and nanotechnology: From the elementary particles to the periodic table of the elements *AIP Conference Proceedings* **1637** 1100-1109

[5] Trell E, Edeagu S and Animalu A 2017 Geometric Lie Algebra in Matter, Arts and Mathematics with Incubation of the Periodic System of the Elements *AIP Conference Proceedings* **1798** 020162 1-14, and *Mathematics in Engineering, Science and Aerospace* **8** 215-237

[6] Trell E, Edeagu S and Animalu A 2017 Self-organized isotropic vector matrix translation apparatus for realization of the electron, nucleon, and periodic system. Physical Interpretations of Relativity Theory, Bauman Moscow State Technical University, July 3-7 2017, Moscow.

[7] Animalu A, Edeagu S, Akpojotor G, and Trell E 2017 Semiology of Linguistics and Geometric Lie Algebra Foundation of Atomic Structure and Periodic System. Physical Interpretations of Relativity Theory, Bauman Moscow State Technical University, July 3-7 2017, Moscow.

[8] *http://www.encyklopediaofmath.org/index.php/Lie-admissible_algebra*

[9] Santilli RM 1998 Isotopic, genotopic and hyperstructural liftings of Lie's theory and their isoduals. *Algebras Groups and Geometries* **15** 473-495

[10] Santilli RM 2008 *Hadronic Mathematics, Mechanics and Chemistry, volumes I, II, II, IV and V* (International Academic Press, internet open accessible)

[11] Davvaz B, Santilli RM and Vougiouklis 2013 Multi-valued hypermathematics for characterization of matter and antimatter systems. *J. Comput. Meth. Sci. Eng.* **13** 37-50

[12] Schrödinger E 1926 Quantisierung als Eigenwertsproblem I *Annalen der Physik* **79** 361-376

[13] Schrödinger E 1926 Quantisierung als Eigenwertsproblem II *Annalen der Physik* **79** 489-527

[14] Crull E and Bacciagaluppi G 2011 Translation of W. Heisenberg Ist eine deterministische Ergänzung der Quantenmechanik möglich? *http:// Philsci-archive.pitt.edu/8590/1/Heis1935-EPR-Final-translation .pdf.*

[15] Balchin D, Miličić G, Strauss M, Hayer-Hartl M, and Hartl FU 2018 Pathway of Actin Folding Directed by the Eukaryotic Chaperonin TRiC. *Cell* **174** 1507-1521

[16] Lie M S 1871 *Over en classe geometriske transformationer* (Kristiania (now Oslo) University: Ph.D. Thesis)

[17] Trell E 1998 Marius Sophus Lie's doctoral thesis Over en classe geometriske transformationer *Algebras Groups and Geometries* **15** 395-445 and *hadronicpress.com/lie.pdf* (internet open accessible).

[18] Trell E 1983 Representation of particle masses in hadronic SU(3) transformation diagram *Acta Phys. Austriaca* **55** 97-110

[19] Trell E 1990 Geometrical reproduction of (u, d, s) baryon, meson, and lepton transformation symmetries, masses, and channels *Hadronic J.* **13** 277-297

[20] Trell E 1991 On rotational symmetry and real geometrical representations of the elementary particles with special reference to the N and Δ Series *Phys. Essays* **4** 272-283

[21] Trell E 1992 Real forms of the elementary particles with a report of the Σ resonances. *Phys. Essays* **5** 362-373

[22] Trell E 1998 The eightfold eightfold way: Application of Lie's true geometriske transformationer to the elementary particles *Algebras Groups and Geometries* **15** 447-471

[23] Trell E 2008 Elementary particle spectroscopy in regular solid rewrite. *AIP Conference Proceedings* **1051** 127-141

[24] Trell E 2009 Back to the Ether In: *Ether, Spacetime & Cosmology* vol 3, ed C Duffy and M C Levy (Montreal:Apeiron) pp 339-387

[25] Trell E 2012 Mathemimetics II. Demonstratio Mirabilis of FLT by infinitely ascending cubical crystal growth *AIP Conference Proceedings* **1479** 2142-2146

[26] Trell E 2013 3–d realization of τ, and *c* and *b* hadrons in endogenous parity with standard model *Afr. J. Phys.* **3** 24-47

[27] Trell E 2013 Digital outline of elementary particles via a root space diagram approach. *J. Comput. Meth. Sci. Eng.* **13** 245-270

[28] Trell E, Akpojotor G, Edeagu S and Animalu A 2017 Stochastic wavepacket tessellation of atomic and periodic table build in structural $R^3 \times SO(3)$ configuration space. *AIP Conference Proceedings* **2046** 020026 1-10

[29] Grunch Net Octet Truss *http://www.grunch.net/synergetics/octet.html*

[30] Rowlands P 2018 Constructing the Standard Model fermions. Advances in Fundamental Physics, 11th International Symposium Honouring Noted Mathematical Physicist Jean-Pierre Vigier, Liege, August 6-9, 2018.

[31] Filatov VV and Gorelik. VS 2017 The Resonance g+ g→pg Conversion in the *f*-block of the Periodic Table. International Meeting Physical Interpretations of Relativity Theory, Bauman Moscow State Technical University, July 3-7 2017, Moscow.

[32] Musser G 2018 What is Spacetime? *Nature* **557** S3 – S6

[33] Dandekar P D and Doherty M F 2014 Imaging crystallization *Science* **344** 705-706

[34] Lupulescu A I and Rimer J D 2014 In situ imaging of Silicate-1 surface growth reveals the mechanism of crystallization *Science* **344** 729-732

[35] al Ajouni RA 2005 Development and evaluation of a digital tool for virtual reconstruction of historic Islamic geometric patterns . Ph. D. Dissertation, Texas A&M University College Station

[36] Bédaride N and Fernique Th 2013 Amman-Beenker tilings revisited In: *Aperiodic Crystals* ed S Schmid, RL Witherts and R Lifshitz (Netherlands: Springer)

[37] Animalu A and Acholonu C O 2010 Hyperspace and the torus revisited: An African perspective of the theory of everything *Afr. J. Phys.* **3** 31-50

[38] Animalu A 2010. Complementary duality of leptons and baryons *Afr. J. Phys.* **3** 51-62

[39] Animalu A and Animalu N C 2010 Space-time geometry of a torus for a Lorentz and conformal invariant string theory without divergences *Afr. J. Phys.* **3** 63-93.

[40] Animalu A 2013 Geno-Bragg's law and 10*Å~10 representation of SU(3) symmetry for quasicrystal structures *J. Comput. Meth. Sci. Eng.* **13** 1-17

[41] Stanford Encyclopedia of Physics Descartes Physics *http://plato.stanford.edu/ entries/descartes-physics*

[42] Strassler M J and Zurek K M 2007 Echoes of a hidden valley at hadron collider. *Phys. Letters B* **651** 374-379

[43] Jacak B V and Müller B W 2012 The exploration of hot nuclear matter *Science* **337** 310-314

[44] Martin F, Fernandez J, Havermeier T, Foucar I and Weber Th 2007 Single photon-induced symmetry breaking of H_2 dissociation. *Science* **315** 629-633

HADRONIC JOURNAL 41, 335 - 347 (2018)
DOI 10.29083/HJ.41.04.2018

MASS PREDICTIONS AND LIFETIME FORMULAS OF HEAVY FLAVOR HADRONS, AND SIMPLIFY OF SUPERSYMMETRY

Yi-Fang Chang
Department of Physics, Yunnan University
Kunming, 650091, China
yifangch@sina.com

Received June 24, 2018
Revised February 22, 2019

Abstract

First, we discuss the modified accurate mass formula, and applied to heavy flavor hadrons, and derive some predictions, m(Ω_{cc}^{+})=3950.7 or 3908MeV, and $m(\Xi_{bb})$=10396.8 or 10348.9MeV, etc. It is a quantitative and testable theory.

Next, based on the new data, we propose various lifetime formulas of heavy flavor hadrons, which very agree with experiments. This is a new method on lifetime of hadrons described by quantum numbers, and can be unified for mass and lifetime. Finally, we discuss an approximate simplified supersymmetry theory based on the known symmetrical particles and their excited states.

Key words: particle, mass formula, lifetime formula, heavy flavor hadron, supersymmetry.

Copyright © 2018 by Hadronic Press, Inc., Palm Harbor, FL 34684, USA

1. Introduction

It is well-known that the theoretical base of particles is the standard model:

$$\begin{matrix} q=(2/3)e & -(1/3)e & -e & 0 \\ \begin{pmatrix} u \\ c \\ t \end{pmatrix} & \begin{pmatrix} d \\ s \\ b \end{pmatrix} & \begin{pmatrix} e \\ \mu \\ \tau \end{pmatrix} & \begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} \end{matrix}. \qquad (1)$$

The total charge number of per generation quarks is 3(2/3-1/3)=1, and the total charge number of per generation leptons is yet (-1+0)=-1. The total charge of per generation quark-lepton is 0. This is very symmetrical and beautiful theory.

After particles are classified, mass and lifetime are two main characters for any particles. In this paper, we discuss various mass and lifetime formulas, esp., for heavy flavor hadrons, and a simplified supersymmetry theory.

2. Accurate Mass Formula of Hadrons and Prediction

Based on two moving states of the emergence string: oscillation and rotation, we derived its quantum potential and the equation, whose energy spectrum is the GMO mass formula:

$$M = M_0 + AS + B[I(I+1) - \frac{S^2}{4})], \qquad (2)$$

in which must assume that $M = m^2$ for mesons, and its modified accurate mass formula [1-3]:

$$M = M_0 + AS + B[I(I+1) - \frac{S^2}{2}]. \qquad (3)$$

Based on the standard model and on the symmetry of s and c quarks in the same generation, we supposed that the hadrons, which made of u, d and c quarks, are also the SU(3) symmetry and are classified by octet and decuplet [4,2,3]. It is a subgroup of SU(4) of u, d, s and c quarks. Such we assume that these masses of the octet obey the corresponding simple mass formulas only by S→C in Eqs.(2) and (3):

$$M = M_0 + AC + B[I(I+1) - (C^2/4)], \quad (4)$$

or $$M = M_0 + AC + B[I(I+1) - (C^2/2)]. \quad (5)$$

Since when m(N)=939, $m(\Lambda_c^+) = 2285, m(\Sigma_c) = 2453 MeV$, from the two corresponding mass formulas (4) and (5) we predicted $m(\Xi_{cc}) = 3715$ or $3673 MeV$ [4,2,3]. In 10 July 2017 LHC announced to observe a new doubly charmed baryon $\Xi_{cc}^{++} = ucc$, whose mass is $3621.4 \pm 0.8 MeV$, and decay mode is $\Xi_{cc}^{++} \to \Lambda_c^+ K^- \pi^+ \pi^+$ [5,6]. New experimental data agree more on Eq.(5) and (3), whose error only is (3673–3621)/3621=1.4%. Moreover, there should have $\Xi_{cc}^{+} = dcc$, both form I=1/2 doublet with near mass, and one of decay modes is $\Xi_{cc}^{+} \to \Lambda_c^+ K^- \pi^+ \pi^0$ [7]. In 1994 we predicted that "if the experiments derive this mass, it will show that our theory (hadrons made of u, d and c quarks are the SU(3) symmetry) is right"[4].

According new experimental data m(p)=938.3, $m(\Lambda_c^+) = 2286.5$, $m(\Sigma_c^+) = 2452.9$ and $m(\Xi_{cc}^{++}) = 3621.4$ MeV[6], it agrees with the mass relation

$$4(p + \Xi) = 7\Lambda + \Sigma \ (18238.8 = 18458.4), \quad (6)$$

whose error is (18458.4–18238.8)/ 18458.4=1.19%.

Further, for the $J^p = 3^+/2$ baryons form also a decuplet:

$\Delta^{++}, \Delta^+, \Delta^0, \Delta^-$ (I=3/2); $\Sigma_c^{++}, \Sigma_c^+, \Sigma_c^0$ (I=1); $\Xi_{cc}^{++}, \Xi_{cc}^{+}$ (I=1/2)

and $\Omega_{ccc}^{++} = ccc$ (I=0).

Their masses are possibly an equal-spacing rule, i.e.

$$M = M_0 + aC. \tag{7}$$

Of course, these baryons obey probably the more accurate mass formulas

$$M = M_0 + aC + bC^2, M = M_0 + a'I + b'I^2, \tag{8}$$

which correspond to Eqs.(2) and (5).

The $J^p = 0^-$ octet of heavy flavor mesons are $\pi^{+,-}, \pi^0 (I = 1); D^+ = c\bar{d}$, $D^0 = c\bar{u} (I = 1/2)$ and their antiparticles; $\eta'_c = a(u\bar{u} + d\bar{d}) + b(c\bar{c})$. If their mass relation is:

$$4\text{m(D)} = m(\pi) + 3m(\eta'_c) \text{ or } 8\text{m(D)} = m(\pi) + 7m(\eta'_c), \tag{9}$$

so $m(\eta'_c)$ =2444 or 2114*MeV* since m(π)=137, m(D) =1867*MeV*. For the $J^p = 1^-$ octet, $m(\rho) = 770, m(D^+) = 2010$ *MeV*, so $m(\eta'_c)$ =2423 or 2187*MeV*.

For the $J^p = 1^+/2$ baryons, m($\Xi_c^+(usc)$)=2467.7*MeV*, m($\Xi_c^0(dsc)$)= 2471.7*MeV* (I=1/2), m($\Omega_c(ssc)$)=2695.2*MeV*.

These octets and decuplet are a certain cross section of the diagrams of the SU(4) multiplets, respectively. For the $J^p = 3^+/2$ baryons, probably, the masses of the triplet $\Sigma^+, \Sigma^0, \Sigma^-$ (I=1), the doublet $\Xi_c^+(usc), \Xi_c^0(dsc)$ (I=1/2), and the singlet $\Omega_{cc}^+ = scc$ (I=0) are approximately an equal-spacing rule, it is the second series of series of heavy flavor baryons. Then the masses of $\Omega^- = sss, \Omega_c^0 = ssc, \Omega_{cc}^+$ and Ω_{ccc}^{++} are only four hadrons for mixtures of second generation, and their masses are should be equal-spacing too. It is the third series of heavy flavor baryons. For the $J^p = 3^+/2$ baryons, m(Σ_c)=2518, m(Ξ_c)=2646,

so m($\Omega_c(ssc)$)=2766*MeV*, these masses obey equal-spacing rule. Such based on the known masses of $3^+/2$ baryons including c quark [6], other masses of baryons will be able to be estimated. Because Σ_c(uuc,2518)– Δ(uuu,1232)= 1286≙m(c)–m(u), so m(Ξ_{cc})=3804 and m(Ω^{++}_{ccc})=5090. From the third series, we obtain m(Ω^-)=1672.1, m(Ω^0_c)=2811.4, m(Ω^+_{cc})=3950.7 and m(Ω^{++}_{ccc})=5090. But, from the second series the known m(Σ)=1385 and. m(Ξ_c)=2646.6, so c–u≙1261.6 and m(Ω^+_{cc})=3908.2. Both m(Ω^+_{cc}) are different due to different of spin. Of course, these baryons obey probably the more accurate mass formulas (8).

Such any one of masses of $3^+/2$ baryons including c quark is known again, for example, for $\Sigma_c(2518.1)MeV$ ($J^p = 3^+/2$) [6], then other five masses of other baryons will be able to be estimated.

baryon	Ω^-	Ξ_c	Δ	Σ_c	Ξ_{cc}	Ω_c	Ω^+_{cc}	Ω^{+++}_{ccc}
m(exp)	1672	2646	1232	2518				
m(*est*)	*input*	2646	*input*	*input*	3804	2811	3951	5090

Therefore, by using different ways we predict different m(Ω^+_{cc})=3950.7, or 3908*MeV*, etc.

For the doublet $\Xi^+_c = usc, \Xi^0_c = dsc$ (I=1/2, S= –1, C=1) and both masses are 2467.9 and 2471.9*MeV*, the singlet $\Omega^0_c = ssc$ (I=0, S= –2, C=1) and its mass is 2695.2±1.7*MeV*, and the singlet $\Omega^+_{cc} = scc$ (I=0, S= –1, C=2), we can assume that the simplest mass formula is:

$$M = M_0 + A(C-S) + B[I(I+1) - (C-S)^2/2], \qquad (10)$$

or $$M = M_0 + A(C-S) + B[I(I+1) - (C^2+S^2)/2]. \qquad (11)$$

Some similar multiplets and mass formulas exist possibly in baryons and mesons including b or t quarks. For instance, both mass spectra of $\psi = c\bar{c}$ and $\Upsilon = b\bar{b}$ are similar; as in the neutral kaon system, $D^0 - \overline{D^0}$ and $B^0 - \overline{B^0}$ mixings should exist.

Further, this method will be able to be extended to other potentials and other heavy flavor hadrons. For example, based on the symmetry of quarks model, we may suppose that the hadrons, which made of u, d and b quarks, and of u, d and t all are the SU(3) symmetry. It is a subgroup of SU(4) of u, d, b and t quarks. Such the eight $J^p = 1^+/2$ baryons form also an octet:

p=uud, n=udd(I=1/2); $\Lambda_b^0 = udb(I=0)$;

$\Sigma_b^+ = uub, \Sigma_b^0 = udb, \Sigma_b^- = ddb(I=1)$; and $\Xi_b^0 = ubb, \Xi_b^- = dbb(I=1/2)$.

Such the corresponding mass formulas are:

$$M = M_0 + aB + b[I(I+1) - (B^2/4)], \qquad (12)$$

or $$M = M_0 + aB + b[I(I+1) - (B^2/2)]. \qquad (13)$$

It is known the m(Λ_b)=5620, m(Σ_b)=5811.5(5811.3, 5815.5)*MeV* [6]. From the two corresponding mass formulas, we may predict $m(\Xi_{bb})$ =10396.8 or 10348.9*MeV*, whose error is probably bigger due to weaker symmetry between first (u,d) and third generations (t,b).

Generally, based on the symmetry of quark model we can suppose that the hadrons, which made of s, c and b quarks are the SU(3) symmetry. Similar, the hadrons made of s, c and t quark are also the SU(3) symmetry. Both are two subgroups of SU(4) of s, c, b and t quarks, but these quarks are all I=0 and very

unstable. These mass formulas are possibly:

$$M = M_0 + aS + a'C + a''B + bS^2 + b'C^2 + b''B^2, \tag{14}$$

or $$M = M_0 + aS + a'C + a''B + b(S + C + B)^2. \tag{15}$$

The mixtures of three generations are m($\Xi_b^0 = usb$)=5791.9*MeV*, m($\Xi_b^- = dsb$)=5797.0 *MeV*(I=1/2). Other hadrons are m($\Lambda_b^0(udb)$)=5619.6*MeV*, m(Ω_b^- (ssb))=6046.1*MeV*, etc[6].

In a word, our research based some symmetries among different generations is a quantitative and testable theory [8].

3. Lifetime Formulas of Heavy Flavor Hadrons

Based on the Y-Q and I-U symmetries between mass and lifetime on the general SU(3) theory, we obtained the lifetime formulas of hyperons and mesons [1-3]:

$$\tau = A[2U(U+1) - Q/2], \tag{16}$$

and $$\tau = A'[(1/2) + 2U(U+1) - Q/2 - Q^2/3]. \tag{17}$$

They agree better with experiments [6].

Generally, lifetime of various hadrons can be classified by different times:

Lifetimes of mesons K_L^0, π^-, K^+ are 10^{-8} sec.

Lifetimes of hyperons $\Xi^0, \Xi^-, \Sigma^-, \Sigma^+$ and K_S^0, Ω^- are 10^{-10} sec.

Lifetimes of heavy flavor hadrons mainly are 10^{-13} sec.

Lifetime of π^0 is 8.4×10^{-17} sec.

Lifetime of Σ^0 is 7.4×10^{-20} sec.

Lifetimes of J/ψ and Υ are KeV.

Lifetimes of other hadron-resonances mainly all are MeV.

For heavy flavor hadrons we propose their lifetime formulas. For Ξ_c^+(usc), Λ_c^+(udc), Ξ_c^0(dsc) and Ω_c^0(ssc), it is:

$$\tau = [1.4(2I - C^2) - S + 3.4Q] \times 10^{-13}. \tag{18}$$

Then $\tau(\Xi_c^+)$=4.4, $\tau(\Lambda_c^+)$=2, $\tau(\Xi_c^0)$=1 and $\tau(\Omega_c^0)$=0.6, and the experimental data are (4.42 ± 0.26), (2.00 ± 0.06), (1.12 ± 0.13) and $(0.69 \pm 0.12) \times 10^{-13}$ [6]. They all agree within the range of error. Further, for $\tau(\Xi_{cc}^{++}, ucc)$=2.6 by this formula (18), it agrees accurately with the experimental data $(2.56 \pm 0.37) \times 10^{-13}$ [9].

For Λ_b^0(udb), Ξ_b^-(usb), Ξ_b^0(dsb) and Ω_b^-(ssb), we propose the lifetime formula:

$$\tau = [14.8B^2 - (I + Q - \frac{1}{2}S)] \times 10^{-13}. \tag{19}$$

Then $\tau(\Lambda_b^0)$=14.8, $\tau(\Xi_b^-)$=15.8, $\tau(\Xi_b^0)$=14.8 and $\tau(\Omega_b^-)$=16.8, and the experimental data are (14.70 ± 0.10), (15.71 ± 0.40), (14.79 ± 0.31) and $(16.4 \pm 1.8) \times 10^{-13}$ [6]. They all agree within the range of error.

For $D^+(c\bar{d}), D^0(c\bar{u})$ and $D_s^+(c\bar{s})$, we propose the lifetime formula:

$$\tau = [4.1 + 6.3(2I - C^2 + Q) - S] \times 10^{-13}. \tag{20}$$

Then $\tau(D^+)$=10.4, $\tau(D^0)$=4.1 and $\tau(D_s^+)$=5.1, and the experimental data are (10.4 ± 0.07), (4.101 ± 0.015) and $(5.04\pm0.04)\times10^{-13}$ [6]. They all agree within the range of error.

For $B^+(u\bar{b}), B^0(d\bar{b})$, $B_s^0(s\bar{b})$ and $B_b^+(c\bar{b})$, we propose the lifetime formula:

$$\tau = [15+5.5(2I-C^2-B^2-S)+Q]\times10^{-13}. \qquad (21)$$

Then $\tau(B^+)$=16, $\tau(B^0)$=15, $\tau(B_s^0)$=15 and $\tau(B_b^+)$=5, and the experimental data are (16.38 ± 0.04), (15.20 ± 0.04), (15.09 ± 0.04) and $(5.07\pm0.09)\times10^{-13}$ [6]. They all very agree.

We may unify these lifetime formulas for the heavy flavor hadrons to:

$$\tau = [\tau_0 + a(2I-C^2-B^2) - bS + cQ]\times10^{-13}. \qquad (22)$$

It is a new method on lifetime of hadrons described by quantum numbers. They are symmetrical with the corresponding mass formulas, and can be unified for mass and lifetime.

4. Supersymmetry and Its Simplify

Supersymmetry is a very beautiful theory, and it combines string, and derives the superstring. But so far any particles of supersymmetry are not observed. We derived some new representations of the supersymmetric transformations, and introduced the supermultiplets. Based on these representations, Graded Lie Algebras and various formulations (equations, commutation relations, propagators, Jacobi identities, etc.) of bosons and fermions may be unified. On the one hand, the mathematical characteristic of particles is proposed: bosons correspond to real number, and fermions correspond to imaginary number, respectively. Such fermions of even (or odd) number form bosons (or fermions), which is just consistent with a relation between imaginary and real number. The imaginary number is only

included in the equations, forms, and matrixes of fermions. It is connected with relativity. On the other hand, the unified forms of supersymmetry are also connected with the statistics unifying Bose-Einstein and Fermi-Dirac statistics, and with the possible violation of Pauli exclusion principle; and a unified partition function is obtained [10,11]. Moreover, three quarks may be described by the Borromean rings [12]. We discussed some unifications in particle physics. The quantum statistics is unified by the nonlinear equations. Based on the gauge groups, various unifications of interactions are researched. A developed direction of particle physics and modern science is possibly the higher dimensional complex space [10-12].

Now we discuss an approximate simplified supersymmetry theory based on the known symmetrical particles and their excited states, and the Regge trajectory formula S=AJ+B.

It is known that baryons (J=1/2,3/2) and mesons (J=0,1) possess symmetry.

For SU(3) octet of u,d,s and their excited states:

J=1/2	$p,n;\Lambda,\Sigma^+,\Sigma^0,\Sigma^-;\Xi^0,\Xi^-$ (in octet baryons first generation 2, second generation 6)
J=0	$\pi^0,\pi^\pm;K^\pm,K^0;\eta$ (in five mesons first generation 2, second generation 3)

J=3/2	$\Delta;\Sigma^*;\Xi^*;\Omega(sss)$ (in decuplet baryons first generation 4, second generation 6)
J=1	$\rho(770),\omega(782)$; $(s\bar{s})$

For leptons there are:

J=1/2	$e,\nu;\mu,\tau,\nu_\mu,\nu_\tau$ (six leptons first generation 2, second-third generation 4)
J=1	$\gamma;W^\pm,Z^0$ (1 and 2)

J=2, graviton.

In a word, bosons are all the degenerate states.

For SU(3) octet of u,d,c and their excited states possess structures of complete symmetry:

J=1/2	$p,n;\Lambda_c^+,\Sigma_c^{++},\Sigma_c^+,\Sigma_c^0;\Xi_c^+,\Xi_c^0$ (in octet baryons first generation 2, second generation 6)
J=0	$\pi^0,\pi^{\pm};D^0,D^*;\eta_c(c\bar{c})$ (in five mesons first generation 2, second generation 3)

Second generation has the mixtures $\Omega_c^0(ssc)$, and (scc), (ccc) for J=1/2; $D_s^+(c\bar{s})$ for J=0.

For SU(3) octet of u,d,b and their excited states possess structures of complete symmetry:

J=1/2, known baryons are $p,n;\Lambda_b^0(udb);\Xi_b^0(usb),\Xi_b^-(dsb)$; should yet have $\Sigma(uub,udb,ddb)$. (in octet baryons first generation 2, third generation 6);

J=0, $\pi^0,\pi^{\pm};B^+(u\bar{b}),B^0(d\bar{b})$ (in four mesons first generation 2, second generation 2).

Moreover, J=1, $\Upsilon(b\bar{b})$.

We combine supersymmetry and the standard model (1). Suppose the second and third generations of quark-lepton are the different excited states of the first generation. This will be the simplest particle model.

First generation

J=1/2	p(uud), n(udd) are stable	J=3/2	$\Delta^{++}(uuu),\Delta^-(ddd)$
J=0	$\pi^+(u\bar{d}),\pi^0(u\bar{u},d\bar{d})$		

Second generation

J=1/2	$\Omega_c^0(ssc)$, (scc)	J=3/2	$\Omega^-(sss), X^{++}(ccc)$
J=0	$D_s^+(c\bar{s}),(s\bar{s}),\eta_c(c\bar{c})$	J=1	$J/\psi(c\bar{c})$

Third generation

J=1/2	(bbt), (btt)	J=3/2	They are probably (bbb), (ttt)
J=0	$(t\bar{b}),(b\bar{b}),(t\bar{t})$	J=1	$\Upsilon(b\bar{b})$

Therefore, the second and third generations are completely similar to the first generation. Three quarks are the same, probably all J=3/2.

From the second generation begins, some mixing states of first and second generations exist:

J=1/2	(uus), (uds), (dds); (uss), (dss)	And (uuc), (udc), (ddc); (ucc), (dcc)
J=0	$K^+(u\bar{s}),K^0(d\bar{s})$	And $D^+(c\bar{d}),D^0(c\bar{u})$

From this begins existence of the substable states.

Further, some mixing states of first and third generations exist:

J=1/2	(uub), $\Lambda_b^0(udb)$, (ddb); (ubb), (dbb)	And (uut), (udt), (ddt); (utt), (dtt)
J=0	$B^+(u\bar{b}),B^0(d\bar{b})$	And $(u\bar{t}),(d\bar{t})$

And there are some mixing states of second and third generations:

J=1/2	(ssb), (scb), (ccb); (sbb), (cbb)	And (sst), (sct), (cct); (stt), (ctt)
J=0	$B_s^0(s\bar{b})$, $B_b^+(c\bar{b})$	And $(s\bar{t}),(c\bar{t})$

Moreover, there are some mixtures of first-second-third generations:

$\Xi_b^0(usb),\Xi_b^-(dsb)$, etc.

Quarks have three generations, gluons should have three generations. Or second and third generation quarks are excited states of the first generation quarks,

so the corresponding second and third generation gluons will also be the first generation excited states.

References

[1] Yi-Fang Chang, *New Research of Particle Physics and Relativity*. Yunnan Science and Technology Press. 1989. Phys.Abst. **93**,1371(1990).

[2] Yi-Fang Chang, arXiv:0803.0087.

[3] Yi-Fang Chang, International Review of Physics. **6**, 261(2012).

[4] Yi-Fang Chang, J. Yunnan University. **16**,100(1994). Che. Abs. **123**,840(1995).

[5] R. Aaij, B. Adeva, M. Adinolfi, et al. (LHCb Collaboration). Phys.Rev.Lett. **119**,112001 (2017).

[6] M. Tanabashi, *et al.* Particle Data Group. Phys.Rev. D**98**, 030001(2018).

[7] Yi-Fang Chang, J. Yunnan University. **39**, Inside front-back cover(2017).

[8] Yi-Fang Chang, Algebras, Groups, and Geometries. **34**, 273(2017).

[9] R. Aaij, *et al.* (LHCb Collaboration), Phys.Rev.Lett. **121**,052002 (2018).

[10] Yi-Fang Chang, J. Yunnan University. **25**,37(2003).

[11] Yi-Fang Chang, 2008, arXiv:0804.0267.

[12] Yi-Fang Chang, *International Journal of Modern Mathematical Sciences*. **10**,75(2014).

HADRONIC JOURNAL 41, 349 - 370 (2018)
DOI 10.29083/HJ.41.04.2018

ON SEPARATION OF EXCHANGE TERMS FOR FOUR-POTENTIAL ACOUSTIC SH-WAVE CASE WITH DEPENDENCE ON GRAVITATIONAL PARAMETERS

Aleksey Anatolievich Zakharenko
International Institute of Zakharenko Waves (IIZWs)
660014, ul. Chaikovskogo, 20-304, Krasnoyarsk, Russia
aazaaz@inbox.ru

Received February 7, 2019

Abstract

One of major achievements in modern physics is investigations of complex systems consisting of mechanical, electrical, magnetic, gravitational, and cogravitational subsystems. The recently developed theory provides the coupling coefficient among these subsystems. It is called the coefficient of the electromagnetogravitocogravitomechanical coupling (CEMGCMC) K^2_{emgc}. This coupling coefficient is one of the very important characteristics of a studied solid material and all the four-potential shear-horizontal acoustic waves depend on this coefficient. This report analytically studies the CEMGCMC concerning separation of several exchange terms. It is also discussed the possible propagation speeds such as the well-known speed of light in a vacuum for the purely electromagnetic wave and purely gravitational wave. However, some exchange mechanisms between the electromagnetic and gravitational subsystems can result in the existence of the other exchange speeds, with which generated signals representing neither purely electromagnetic nor purely gravitational waves can propagate in a vacuum with speeds several orders larger than the speed of light. The evaluated maximum value of this speed must be below ~ 10^{27} m/s representing the speed with which a signal can cross for one second from one boundary of our Universe to the opposite. This can mean that such signals once generated inside of our Universe can instantly reach any other point in the Universe. It is also hoped that this theoretical work will contribute to the development of such new research discipline as the gravitational engineering.

Keywords: Continuous media; Gravitational effects; Magnetoelectric effect; Four-potential coupling problem; Exchange terms.

Copyright © 2018 by Hadronic Press, Inc., Palm Harbor, FL 34684, USA

1 Introduction

Investigations of acoustic wave propagation coupled with the electrical, magnetic, gravitational, and cogravitational potentials (i.e. four-potential acoustic wave) represent a complicated problem. For this problem there are a lot of material parameters that can contribute in the wave motions. However, it is a pleasure to deal with a single material parameter that can significantly simplify the studying subject. This single material parameter is called the coefficient of the electromagnetogravitocogravitomechanical coupling (CEMGCMC) K^2_{emgc}. This coupling coefficient represents a very important characteristic of a studied solid material. It depends on all the material parameters, but the mass density ρ. The CEMGCMC is an indicator of coupling among the mechanical, electrical, magnetic, gravitational, and cogravitational subsystems. For instance, the four-potential shear-horizontal (SH) surface [1], interfacial [2], and plate [3] acoustic waves can depend on this material parameter.

The examination of propagation of four-potential acoustic waves has the following peculiarity: the speed of any acoustic wave in a solid is five orders smaller than the speed of the electromagnetic wave in the solid. Also, the speed of the electromagnetic wave in any solid must be (slightly) smaller than the speed of light in a vacuum. Therefore, the quasi-static approximation can be applied for this case. In 2016, a large research group consisting of more than one thousand of collaborators [4] has experimentally demonstrated that the speeds of the gravitational and electromagnetic waves in a vacuum are equal. The gravitational wave existence was predicted by Einstein [5] in 1916. Heaviside [6] in 1893 has first focused an attention of researchers on an analogy between the electromagnetic and gravitational phenomena. Therefore, the famous book by Jefimenko [7] published in 2006 has further developed Newton's theory of

gravitation assuming that Newton's gravitation coexists with cogravitation. The coupling between the gravitation and cogravitation can result in the gravitational wave propagation in a vacuum. In 2016, Füzfa [8] has discussed some ideas of evaluation of interactions between the electrical or magnetic subsystem with the gravitational or cogravitational subsystem. This can allow researchers in the future to control some changes in the gravitational or cogravitational subsystem by created changes in the electrical or magnetic subsystem, i.e. some artificial gravitational fields can be created in a laboratory at the Earth conditions. It is necessary to state here that any type of energy and changes in energy actually produce gravitation in the same way. And any type of wave motion carries some energy over the way from the wave generator to the wave detector. It is obvious that the CEMGCMC combines contributions from each of the mechanical, electrical, magnetic, gravitational, and cogravitational subsystems. These contributions for different solid materials can be different. And it is expected that these contributions can show even a dramatic difference for some suitable solids.

With the CEMGCMC, the theoretical investigations of this work obtain and discuss several exchange terms. These terms couple the possible exchange processes that can exist among the subsystems. The following section provides the analytical expressions that can be useful for more complete understanding of some aspects of the studied complex system consisting of the mechanical, electrical, magnetic, gravitational, and cogravitational subsystems. The following section also touches some questions concerning different wave motions in both solids and a vacuum for discussion. The third section mathematically obtains the exchange terms and some problems are discussed in the last section.

2 The material parameters

Consider a solid material, for which the wave motion accumulates nonzero contributions from each of the mechanical, electrical, magnetic, gravitational, and cogravitational subsystems. The reader must be familiar with the cogravitational subsystem that can coexist with gravitational subsystem. This is an analogy to the coexistence of electrical and magnetic subsystems, for instance, in order to form an electromagnetic wave. This analogy was first stated by Heaviside [6]. In this direction, Newton's theory of gravitation created in 1687 was then developed by many researchers, for instance, by Jefimenko [7]. In

2016, both the gravitation and the cogravitation were taken into account in developed theory concerning the acoustic wave propagation in anisotropic solids [1]. With the transversely isotropic crystal of symmetry class 6 *mm*, the velocities of the anti-plane polarized bulk and surface acoustic waves can be respectively calculated with the following formulae [1]:

$$V_{temgc} = \sqrt{C\left(1 + K^2_{emgc}\right)/\rho} \tag{1}$$

$$V_{newSAW} = V_{temgc}\left[1 - \left(\frac{K^2_{emgc}}{1+K^2_{emgc}}\right)^2\right]^{1/2} \tag{2}$$

In definition (1), the velocity V_{temgc} is called the four-potential shear-horizontal bulk acoustic wave (4P-SH-BAW) because the acoustic wave propagation is coupled with the electrical, magnetic, gravitational, and cogravitational potentials. In definition (2), the velocity V_{newSAW} is analogically called the four-potential shear-horizontal surface acoustic wave (4P-SH-SAW) that was recently discovered in paper [1]. In general, an SH-SAW can be treated as an instability of the SH-BAW. In definition (1), the material parameters ρ and C respectively stand for the mass density and the elastic stiffness constant listed in table 1. It is clear seen in expressions (1) and (2) that both the bulk and surface acoustic waves depend on the nondimensional parameter K^2_{emgc} called the coefficient of the electromagnetogravitocogravitomechanical coupling (CEMGCMC).

The coefficient K^2_{emgc} is the very important coupling mechanism and represents a very complicated material parameter depending on all the material parameters listed in table 1, but the mass density ρ. Therefore, this coefficient can be calculated with the following formulae ([1],[2],[3],[9]):

$$K^2_{emgc} = \frac{B_1}{CB_2} \tag{3}$$

where

$$B_1 = e^2(\mu\gamma\eta + 2\beta\lambda\vartheta - \lambda^2\gamma - \beta^2\eta - \vartheta^2\mu) + h^2(\varepsilon\gamma\eta + 2\zeta\xi\vartheta - \vartheta^2\varepsilon - \zeta^2\eta - \xi^2\gamma) + g^2(\varepsilon\mu\eta + 2\alpha\xi\lambda - \lambda^2\varepsilon - \alpha^2\eta - \xi^2\mu) + f^2(\varepsilon\mu\gamma + 2\alpha\beta\zeta - \beta^2\varepsilon -$$

$$\alpha^2\gamma - \zeta^2\mu) + 2eh(\zeta\beta\eta + \xi\gamma\lambda + \vartheta^2\alpha - \alpha\gamma\eta - \zeta\lambda\vartheta - \xi\beta\vartheta) + 2eg(\alpha\beta\eta + \xi\vartheta\mu + \lambda^2\zeta - \alpha\lambda\vartheta - \zeta\mu\eta - \xi\beta\lambda) + 2ef(\alpha\gamma\lambda + \zeta\vartheta\mu + \beta^2\xi - \alpha\beta\vartheta - \zeta\beta\lambda - \xi\mu\gamma) + 2hg(\varepsilon\lambda\vartheta + \zeta\alpha\eta + \xi^2\beta - \alpha\xi\vartheta - \zeta\lambda\xi - \varepsilon\eta\beta) + 2hf(\varepsilon\beta\vartheta + \xi\alpha\gamma + \zeta^2\lambda - \alpha\zeta\vartheta - \zeta\xi\beta - \varepsilon\lambda\gamma) + 2gf(\varepsilon\beta\lambda + \xi\mu\zeta + \alpha^2\vartheta - \alpha\zeta\lambda - \alpha\beta\xi - \varepsilon\mu\vartheta) \quad (4)$$

$$B_2 = (\varepsilon\mu - \alpha^2)(\gamma\eta - \vartheta^2) + (\beta\xi - \lambda\zeta)^2 - (\xi^2\mu\gamma + \beta^2\varepsilon\eta + \lambda^2\varepsilon\gamma + \zeta^2\mu\eta) + +2(\gamma\alpha\xi\lambda + \eta\alpha\beta\zeta + \varepsilon\beta\lambda\vartheta + \mu\zeta\xi\vartheta - \alpha\zeta\lambda\vartheta - \alpha\beta\xi\vartheta) \quad (5)$$

It is necessary here to mention useful physical dimensions of some combinations of the material parameters. With table 1, one can find the following equalities:

$$[\rho/C] = [\varepsilon\mu] = [\gamma\eta] = [\alpha^2] = [\vartheta^2] = [\alpha\vartheta] = [\xi\beta] = [\zeta\lambda] = [s^2/m^2] \quad (6)$$

Indeed, the speed of the electromagnetic wave propagating in a solid can be calculated with the following well-known formula:

$$V_{EM} = \frac{1}{\sqrt{\varepsilon\mu}} \quad (7)$$

Analogically, the propagation speed of the gravitocogravitic wave (gravitational wave) in a solid can be evaluated with the following expression:

$$V_{GC} = \frac{1}{\sqrt{\gamma\eta}} \quad (8)$$

For a solid possessing the magnetoelectric (ME) effect, some exchange between the electrical and magnetic subsystems can be characterized by the electromagnetic constant α. Therefore, the following exchange speed between the subsystems can be calculated:

$$V_\alpha = \frac{1}{\alpha} \quad (9)$$

It is necessary to state here that the exchange speed (9) should be faster than the speed of the electromagnetic wave (7), i.e. $V_\alpha > V_{EM}$ because $\alpha^2 < \varepsilon\mu$ ([10],[11]) should occur. In general, for any ME solid, one can find that $V_\alpha >>$

V_{EM} due to $\alpha^2 << \varepsilon\mu$. The evaluation of these material parameters in table 1 demonstrates that these inequalities occur.

Table 1: The material parameters, their estimated values and fundamental physical dimensions. The propagation direction of the acoustic 4P-SH-wave is perpendicular to the 6-forld symmetry axis of the transversely isotropic material of symmetry class 6 *mm*.

Material parameter	Symbol and [dimension]	Estimated values
Mass density	ρ [kg/m^3]	10^3
Elastic stiffness constant	$C = C_{44} = C_{66}$ [kg/(m×s^2)]	10^9 to 10^{11}
Piezoelectric constant	$e = e_{16} = e_{34}$ [kg$^{1/2}$/m$^{3/2}$]	0.1 to 10
Piezomagnetic coefficient	$h = h_{16} = h_{34}$ [kg$^{1/2}$/(m$^{1/2}$×s)]	0.1 to 10^3
Piezogravitic constant	$g = g_{16} = g_{34}$ [kg/m^2]	10^5 to 10^{10}
Piezocogravitic coefficient	$f = f_{16} = f_{34}$ [s^{-1}]	10^{-16} to 10^{-8}
Dielectric permittivity coefficient (electric constant)	$\varepsilon = \varepsilon_{11} = \varepsilon_{33}$ [s^2/m^2]	10^{-10} to 10^{-8}
Magnetic permeability coefficient (magnetic constant)	$\mu = \mu_{11} = \mu_{33}$ [-]	10^{-6} to 10^{-3}
Electromagnetic constant	$\alpha = \alpha_{11} = \alpha_{33}$ [s/m]	10^{-16} to 10^{-12}
Gravitic constant (gravitoelectric permittivity coefficient)	$\gamma = \gamma_{11} = \gamma_{33}$ [kg×s^2/m^3]	10^{10} to 10^{11}
Cogravitic constant (gravitomagnetic permeability coefficient)	$\eta = \eta_{11} = \eta_{33}$ [m/kg]	10^{-28} to 10^{-27}
Gravitocogravitic constant	$\vartheta = \vartheta_{11} = \vartheta_{33}$ [s/m]	10^{-16} to 10^{-12}
Gravitoelectric constant (electrogravitic constant)	$\zeta = \zeta_{11} = \zeta_{33}$ [kg$^{1/2}$×s^2/m$^{5/2}$]	10^{-8} to 10^{-2}
Cogravitoelectric constant (electrocogravitic constant)	$\xi = \xi_{11} = \xi_{33}$ [s/(kg$^{1/2}$×m$^{1/2}$)]	10^{-45} to 10^{-40}
Gravitomagnetic constant (magnetogravitic constant)	$\beta = \beta_{11} = \beta_{33}$ [kg$^{1/2}$×s/m$^{3/2}$]	10^{-6} to 10
Cogravitomagnetic constant (magnetocogravitic constant)	$\lambda = \lambda_{11} = \lambda_{33}$ [m$^{1/2}$/kg$^{1/2}$]	10^{-40} to 10^{-35}

Table 2: The vacuum parameters borrowed from Yavorsky *et al.* [12], where the value of the vacuum elastic constant was borrowed from work by Kiang and Tong [13]. The other possible exchange parameters for the free space (vacuum) such as α_0, ϑ_0, ζ_0, ξ_0, β_0, λ_0, were theoretically evaluated in the first approximation. This means that the experimentally obtained values of the evaluated vacuum parameters can be even significantly smaller.

Vacuum parameter	Value
Elastic constant	$C_0 = 0.001$ [N/m^2]
Electric constant (dielectric permittivity constant)	$\varepsilon_0 = 0.08854187817 \times 10^{-10}$ [F/m]
Magnetic constant (magnetic permeability constant)	$\mu_0 = 1.25663706144 \times 10^{-6}$ [H/m]
Gravitic constant (gravitoelectric permittivity coefficient)	$\gamma_0 = 1.498334 \times 10^{10}$ [kg×s^2/m^3]
Cogravitic constant (gravitomagnetic permeability coefficient)	$\eta_0 = 0.0742592 \times 10^{-26}$ [m/kg]
Newtonian gravitational (gravitoelectric) constant	$G_0 = 1/\gamma_0 = 0.667408 \times 10^{-10}$ [m^3/(kg×s^2)]
Cogravitational (gravitomagnetic) constant	$M_0 = 1/\eta_0 = 13.46635 \times 10^{26}$ [kg/m]
Speed of light	$C_L = (G_0 M_0)^{1/2} = (\gamma_0 \eta_0)^{-1/2} = (\varepsilon_0 \mu_0)^{-1/2} = 2.997924 \times 10^8$ [m/s]
Electromagnetic exchange constant	$\alpha_0 \sim < 10^{-16}$ [s/m]
Gravitocogravitic exchange constant	$\vartheta_0 \sim < 10^{-16}$ [s/m]
Gravitoelectric exchange constant	$\zeta_0 \sim 10^{-8}$ [kg$^{1/2}$×s^2/m$^{5/2}$]
Cogravitoelectric exchange constant	$\xi_0 \sim 10^{-45}$ [s/(kg$^{1/2}$×m$^{1/2}$)]
Gravitomagnetic exchange constant	$\beta_0 \sim 10^{-6}$ [kg$^{1/2}$×s/m$^{3/2}$]
Cogravitomagnetic exchange constant	$\lambda_0 \sim 10^{-40}$ [m$^{1/2}$/kg$^{1/2}$]

It is also possible to analogically treat the gravitational and cogravitational subsystems. The exchange parameter between these two subsystems can be evaluated by the gravitocogravitic constant ϑ in table1. Therefore, the exchange speed for this case can be calculated as follows:

$$V_\vartheta = \frac{1}{\vartheta} \tag{10}$$

For the gravitocogravitic constant ϑ, it is possible to require the following inequality for speeds (8) and (10): $V_\vartheta > V_{GC}$ because it is also necessary to require that the following inequality should fulfill $\vartheta^2 < \gamma\eta$. Indeed, it is expected that $V_\vartheta >> V_{GC}$ and $\vartheta^2 << \gamma\eta$ must also occur for a real solid.

In a vacuum, it is well-known that an electromagnetic wave propagates with the speed of light, C_L. A gravitocogravitic wave (gravitational wave) also propagates with the same speed in a vacuum. This statement was predicted by Einstein [5] in 1916 and experimentally confirmed in 2016 [4]. Using subscript "0" for all the vacuum material parameters listed in table 2 ([12],[13]), it is possible to write down the following formula for the speed of light in a vacuum:

$$C_L = \frac{1}{\sqrt{\varepsilon_0 \mu_0}} = \frac{1}{\sqrt{\gamma_0 \eta_0}} \tag{11}$$

These vacuum parameters ε_0, μ_0, γ_0, η_0 can be also calculated with Planck's quantum parameters. This is shown in table 3. It is necessary to state that an electromagnetic wave in a vacuum represents a two-potential wave because in this case there are the electrical and magnetic subsystems characterized by the electrical and magnetic potentials. It is also possible to assume that there is an exchange between these two subsystems when an electromagnetic wave propagates in the free space (vacuum). For this exchange between these two subsystems, it is natural to use the exchange parameter such as the vacuum electromagnetic constant α_0. Concerning the gravitocogravitic wave (gravitational wave) propagating in a vacuum, it also represents a two-potential wave because there are the gravitational and cogravitational subsystems characterized by the gravitational and cogravitational potentials. Therefore, it is natural to use the vacuum gravitocogravitic constant ϑ_0 for the exchange between these two subsystems. These vacuum exchange parameters α_0 and ϑ_0 are evaluated in the second table. However, they are not present in the third table because nobody has demonstrated that these vacuum exchange parameters can be derived with Planck's quantum parameters. In a vacuum, the propagation of an electromagnetic wave couples the electrical and magnetic subsystems. This coupling determines the electromagnetic wave propagation due to an energy exchange between two subsystems. Therefore, the vacuum exchange parameters α_0 must exist even it is very small. The same can be stated for the coupling between the gravitational and cogravitational subsystems resulting in the

gravitocogravitic wave (gravitational wave) propagation in a vacuum. Therefore, the vacuum exchange parameter ϑ_0 must be also taken into account. It is also naturally assumed that $V_{\alpha 0} > C_L$ and $V_{\vartheta 0} > C_L$ because it is assumed that $\alpha_0^2 < \varepsilon_0\mu_0$ and $\vartheta_0^2 < \gamma_0\eta_0$, respectively.

Table 3: The expressions of the vacuum parameters ε_0, μ_0, γ_0, η_0 in dependence on Planck's quantum parameters.

Parameter	Value or formula
Planck's force	$F_{Planck} = 1.21027 \times 10^{44}$ [N]
Planck's length	$L_{Planck} = 1.61623 \times 10^{-35}$ [m]
Planck's mass	$M_{Planck} = 2.17651 \times 10^{-8}$ [kg]
Planck's charge	$Q_{Planck} = 1.875545 \times 10^{-18}$ [C]
Planck's speed = Speed of light	$V_{Planck} = C_L = 2.997924 \times 10^{8}$ [m/s]
Planck's time	$T_{Planck} = L_{Planck}/V_{Planck} = 5.39116 \times 10^{-44}$ [s]
Electric constant (dielectric permittivity constant)	$\varepsilon_0 = \frac{1}{4\pi}\frac{1}{F_{Planck}}\left(\frac{Q_{Planck}}{L_{Planck}}\right)^2$
Magnetic constant (magnetic permeability constant)	$\mu_0 = 4\pi F_{Planck}\left(\frac{T_{Planck}}{Q_{Planck}}\right)^2$
Newtonian gravitational (gravitoelectric) constant	$G_0 = \frac{1}{\gamma_0} = F_{Planck}\left(\frac{L_{Planck}}{M_{Planck}}\right)^2$
Cogravitational (gravitomagnetic) constant	$M_0 = \frac{1}{\eta_0} = \frac{1}{F_{Planck}}\left(\frac{M_{Planck}}{T_{Planck}}\right)^2$

Therefore, the corresponding vacuum exchange speeds can be evaluated as follows:

$$V_{\alpha 0} = \frac{1}{\alpha_0} \tag{12}$$

$$V_{\vartheta 0} = \frac{1}{\vartheta_0} \tag{13}$$

Using (5) and (6), one can also find that there are additional two exchange speeds. For a solid, these speeds can be denoted by Λ_1 and Λ_2 in formulae (14) and (15) below. They can be also compared with the speed of light in a vacuum (11) representing a two-potential system discussed above. However, these

speeds are for propagations of two different four-potential systems. Each of two four-potential systems already incorporates the electrical, magnetic, gravitational, and cogravitational subsystems to demonstrate a wave motion caused by a coupling of these four subsystems characterized by the following four potentials: the electrical, magnetic, gravitational, and cogravitational potentials. The exchange speed Λ_1 depends on the following exchange parameters listed in table 1: the gravitoelectric constant ζ and the cogravitomagnetic constant λ. The gravitoelectric constant ζ represents an exchange parameter between the electrical and gravitational subsystems. The cogravitomagnetic constant λ represents an exchange parameter between the magnetic and cogravitational subsystems. This means that the exchange speed Λ_1 is for a system that incorporates all four subsystems such as the electrical, magnetic, gravitational, and cogravitational subsystems. Analogically, the exchange speed Λ_2 depends on the following exchange parameters listed in table 1: the cogravitoelectric constant ξ and the gravitomagnetic constant β. The first material parameter represents an exchange between the electrical and cogravitational subsystems. And the second parameter represents an exchange between the magnetic and gravitational subsystems. So, this is also a four-potential wave.

These additional two exchange speeds read as follows:

$$\Lambda_1 = \frac{1}{\sqrt{\zeta\lambda}} \rightarrow (10^{11} \div 10^{16})C_L \tag{14}$$

$$\Lambda_2 = \frac{1}{\sqrt{\xi\beta}} \rightarrow (10^{12} \div 10^{17})C_L \tag{15}$$

For a vacuum, it is also possible to introduce the corresponding four-potential waves propagating with speeds Λ_{01} and Λ_{02} due to an exchange among the four subsystems such as the electrical, magnetic, gravitational, and cogravitational subsystems. Using the subscript "0" for the corresponding vacuum parameters, it is possible to compare these speeds with the speed of light in a vacuum. These speeds read:

$$\Lambda_{01} = \frac{1}{\sqrt{\zeta_0\lambda_0}} \rightarrow (10^{11} \div 10^{16})C_L \tag{16}$$

$$\Lambda_{02} = \frac{1}{\sqrt{\xi_0 \beta_0}} \rightarrow (10^{12} \div 10^{17}) C_L \tag{17}$$

The vacuum material parameters ζ_0, λ_0, ξ_0, and β_0 are listed and evaluated in the second table. The values for the vacuum parameters are given in the first approximation because nobody has evaluated them before. It is expected that their values can be precisely measured in space experiments and then their values can be also calculated with Planck's quantum parameters listed in the third table.

It is also possible to discuss expression (5) representing the denominator in formula (3) for the coupling coefficient CEMGCMC. The first term consisting of two cofactors in (5) couples the material parameters ε, μ, γ, η and their corresponding exchange parameters α and ϑ. However, expression (5) can be written in a regrouped form, the first term in which can already couple the material parameters ε, μ, γ, η with the exchange parameters ξ and β instead of α and ϑ. This form reads as follows:

$$B_2 = (\varepsilon\eta - \xi^2)(\mu\gamma - \beta^2) + (\alpha\vartheta - \lambda\zeta)^2 - (\vartheta^2\varepsilon\mu + \alpha^2\gamma\eta + \lambda^2\varepsilon\gamma + \zeta^2\mu\eta) + 2(\gamma\alpha\xi\lambda + \eta\alpha\beta\zeta + \varepsilon\beta\lambda\vartheta + \mu\zeta\xi\vartheta - \zeta\xi\beta\lambda - \alpha\beta\xi\vartheta) \tag{18}$$

In addition, expression (5) can be anew regrouped to have the coupling of the material parameters ε, μ, γ, η with the exchange parameters ζ and λ instead of α and ϑ. This form is

$$B_2 = (\varepsilon\gamma - \zeta^2)(\mu\eta - \lambda^2) + (\alpha\vartheta - \beta\xi)^2 - (\vartheta^2\varepsilon\mu + \alpha^2\gamma\eta + \xi^2\mu\gamma + \beta^2\varepsilon\eta) + 2(\gamma\alpha\xi\lambda + \eta\alpha\beta\zeta + \varepsilon\beta\lambda\vartheta + \mu\zeta\xi\vartheta - \zeta\xi\beta\lambda - \alpha\zeta\lambda\vartheta) \tag{19}$$

Three different forms (5), (18), and (19) manifest that exchange speeds (14) and (15) are not less important than the exchange speeds (9) and (10). The following section obtains the exchange terms to demonstrate that the complicated coupling coefficient (3) can be decomposed into several already known coupling coefficients that are more simply.

3 The exchange terms

The coupling coefficient CEMGCMC (3) can be introduced in the following form:

$$K_{emgc}^2 = K_{em}^2 + K_{gc}^2 + K_{ex0}^2 \tag{20}$$

where

$$K_{em}^2 = \frac{\mu e^2+\varepsilon h^2-2\alpha eh}{C(\varepsilon\mu-\alpha^2)} = \frac{e(e\mu-h\alpha)-h(e\alpha-h\varepsilon)}{C(\varepsilon\mu-\alpha^2)} \tag{21}$$

$$K_{gc}^2 = \frac{\eta g^2+\gamma f^2-2\vartheta gf}{C(\gamma\eta-\vartheta^2)} = \frac{g(g\eta-f\vartheta)-f(g\vartheta-f\gamma)}{C(\gamma\eta-\vartheta^2)} \tag{22}$$

Definitions (21) and (22) stand for the coefficient of the magnetoelectromechanical coupling (CMEMC) and the coefficient of the gravitocogravitomechanical coupling (CGCMC), respectively. All the material parameters present in (21) and (22) are listed in table 1. The coupling coefficient CMEMC (21) was previously studied in paper [14]. It is clearly seen in (21) and (22) that the coupling coefficients (21) and (22) have the same form and therefore, they can be studied in the same way.

The last term in expression (20) represents an exchange term that can be obtained with the following formula:

$$K_{ex0}^2 = K_{emgc}^2 - K_{em}^2 - K_{gc}^2 = \frac{B_1(\varepsilon\mu-\alpha^2)(\gamma\eta-\vartheta^2)-B_2(\mu e^2+\varepsilon h^2-2\alpha eh)(\gamma\eta-\vartheta^2)-B_2(\eta g^2+\gamma f^2-2\vartheta gf)(\varepsilon\mu-\alpha^2)}{C(\varepsilon\mu-\alpha^2)(\gamma\eta-\vartheta^2)B_2} \tag{23}$$

Following results of paper [14], the coupling coefficients (21) and (22) can be then decomposed into the following corresponding forms:

$$K_{em}^2 = K_e^2 + K_m^2 + K_{ex1}^2 \tag{24}$$

$$K_{gc}^2 = K_g^2 + K_f^2 + K_{ex2}^2 \tag{25}$$

The first term in expression (24) is called the coefficient of the electromechanical coupling K_e^2 (CEMC). This is a very important characteristic for a purely piezoelectric material. It is defined by

$$K_e^2 = \frac{e^2}{C\varepsilon} \tag{26}$$

The second term in expression (24) is called the coefficient of the magnetomechanical coupling K_m^2 (CMMC). It represents a very important characteristic for a purely piezomagnetic material and is defined by the following form:

$$K_m^2 = \frac{h^2}{C\mu} \tag{27}$$

The third term in expression (24) represents an exchange term defined by the following expression [14]:

$$K_{ex1}^2 = K_{em}^2 - K_e^2 - K_m^2 = \frac{\alpha^2(\mu e^2+\varepsilon h^2)-2\alpha\varepsilon\mu eh}{C\varepsilon\mu(\varepsilon\mu-\alpha^2)} \tag{28}$$

The first term in (25) is called the coefficient of the gravitomechanical coupling K_g^2 (CGMC) and defined by

$$K_g^2 = \frac{g^2}{C\gamma} \tag{29}$$

The second term in (25) is called the coefficient of the cogravitomechanical coupling K_f^2 (CCMC) and defined by

$$K_f^2 = \frac{f^2}{C\eta} \tag{30}$$

The third term (exchange term) in (25) is defined by

$$K_{ex2}^2 = K_{gc}^2 - K_g^2 - K_f^2 = \frac{\vartheta^2(\eta g^2+\gamma f^2)-2\vartheta\gamma\eta gf}{C\gamma\eta(\gamma\eta-\vartheta^2)} \tag{31}$$

Therefore, the nondimensional parameter K_{emgc}^2 (3) called the coefficient of the electromagnetogravitocogravitomechanical coupling (CEMGCMC) can be written in the following final form:

$$K_{emgc}^2 = K_e^2 + K_m^2 + K_g^2 + K_f^2 + K_{ex}^2 \tag{32}$$

where

$$K_{ex}^2 = K_{emgc}^2 - K_e^2 - K_m^2 - K_g^2 - K_f^2 = K_{ex0}^2 + K_{ex1}^2 + K_{ex2}^2 = \frac{B_1\varepsilon\mu\gamma\eta - B_2\gamma\eta(\mu e^2 + \varepsilon h^2) - B_2\varepsilon\mu(\eta g^2 + \gamma f^2)}{C\varepsilon\mu\gamma\eta B_2} \quad (33)$$

In expression (33), the complicated parameters B_1 and B_2 are defined by expressions (4) and (5), respectively. However, the parameter B_2 can be used in equivalent form (18) or (19). It is possible to state that form (32) of the CEMGCMC K_{emgc}^2 (3) is convenient for further analysis. It is clearly seen that the nondimensional material parameters K_e^2 (26), K_m^2 (27), K_g^2 (29), and K_f^2 (30) are quite simple and do not depend on any of the six exchange material parameters α, ϑ, ζ, λ, ξ, and β listed in table 1. In contrast, the exchange parameter K_{ex}^2 (33) in (32) is quite complicated and depends on all the exchange material parameters. There is an interest in investigations of behavior of the CEMGCMC K_{emgc}^2 (32) in dependence on the exchange parameters α, ϑ, ζ, λ, ξ, and β. It is clearly seen in (32) that this problem reduces to the investigations of the exchange parameter K_{ex}^2 (33) as the following function: $K_{ex}^2(\alpha, \vartheta, \zeta, \lambda, \xi, \beta)$. So, it is useful to write down the following equalities:

$$K_{ex}^2(\alpha = 0, \vartheta = 0, \zeta = 0, \lambda = 0, \xi = 0, \beta = 0) = 0 \quad (34)$$

$$K_{emgc0}^2 = K_{emgc}^2\left(K_e^2, K_m^2, K_g^2, K_f^2, K_{ex}^2 = 0\right) = K_e^2 + K_m^2 + K_g^2 + K_f^2 \quad (35)$$

It is possible to treat a solid, for which there are $K_e^2 \neq 0$, $K_m^2 \neq 0$, $K_g^2 \neq 0$, and $K_f^2 \neq 0$. In general, $K_e^2 > 0$ and $K_m^2 > 0$ occur. It is also possible to require that $K_g^2 > 0$ and $K_f^2 > 0$. Therefore there is $K_{emgc0}^2 > 0$ in (35). However there can be the following interesting case:

$$K_{ex}^2(\alpha \neq 0, \vartheta \neq 0, \zeta \neq 0, \lambda \neq 0, \xi \neq 0, \beta \neq 0) = 0 \quad (36)$$

For case (36) there can be $K_{emgc0}^2 > 0$ in (35), too. It is natural that the exchange parameters α, ϑ, ζ, λ, ξ, and β are very small. In comparison with the other material parameters listed in table 1, these very small parameters will change their values more dramatically for a solid under external perturbations

and changes in some boundary conditions. Therefore, it is possible to utilize three dimensionless variables $(\alpha^2\vartheta^2/\varepsilon\mu\gamma\eta)$, $(\zeta^2\lambda^2/\varepsilon\mu\gamma\eta)$, and $(\xi^2\beta^2/\varepsilon\mu\gamma\eta)$ instead of the following six variables possessing physical dimensions: α, ϑ, ζ, λ, ξ, and β. Therefore, it is possible to assume that when any of three dimensionless variables is very slightly changed, the variable's numerator has more significant contribution than the variable's denominator. As a result, it is more convenient to deal with the following three functions depending on one of three dimensionless variables instead of a function of the six variables:

$$K_{ex}^2(\alpha,\vartheta,\zeta,\lambda,\xi,\beta) \to K_{ex}^2\left(\frac{\alpha^2\vartheta^2}{\varepsilon\mu\gamma\eta}\right) \tag{37}$$

$$K_{ex}^2(\alpha,\vartheta,\zeta,\lambda,\xi,\beta) \to K_{ex}^2\left(\frac{\xi^2\beta^2}{\varepsilon\mu\gamma\eta}\right) \tag{38}$$

$$K_{ex}^2(\alpha,\vartheta,\zeta,\lambda,\xi,\beta) \to K_{ex}^2\left(\frac{\zeta^2\lambda^2}{\varepsilon\mu\gamma\eta}\right) \tag{39}$$

where

$$0 < \frac{\alpha^2\vartheta^2}{\varepsilon\mu\gamma\eta} < 1, 0 < \frac{\alpha^2}{\varepsilon\mu} < 1, 0 < \frac{\vartheta^2}{\gamma\eta} < 1 \tag{40}$$

$$0 < \frac{\xi^2\beta^2}{\varepsilon\mu\gamma\eta} < 1, 0 < \frac{\xi^2}{\varepsilon\eta} < 1, 0 < \frac{\beta^2}{\mu\gamma} < 1 \tag{41}$$

$$0 < \frac{\zeta^2\lambda^2}{\varepsilon\mu\gamma\eta} < 1, 0 < \frac{\zeta^2}{\varepsilon\gamma} < 1, 0 < \frac{\lambda^2}{\mu\eta} < 1 \tag{42}$$

It is worth mentioning that functions (37), (38), and (39) correspond to equivalent records (5), (18), and (19), respectively. It is expected that for $\alpha < 0$, $\vartheta < 0$, $\zeta < 0$, $\lambda < 0$, $\xi < 0$, and $\beta < 0$ there is only case (34). However, for $\alpha > 0$, $\vartheta > 0$, $\zeta > 0$, $\lambda > 0$, $\xi > 0$, and $\beta > 0$ there can be already both cases (34) and (36). This can be similar to the significantly more simplified case of $K_{ex1}^2(\alpha) \to K_{ex1}^2(\alpha^2/\varepsilon\mu)$ (28) treated in paper [14] for a piezoelectromagnetic solid. Theoretical work [14] has demonstrated that the exchange parameter K_{ex1}^2 between two zero values $K_{ex1}^2(\alpha = 0) = 0$ and $K_{ex1}^2(\alpha > 0) = 0$ can have only a negative sign that can significantly decrease the value of the CMEMC K_{em}^2

(21). The results of paper [14] can be readily applied for the dependence of the CGCMC K_{gc}^2 (22) on the exchange parameter K_{ex2}^2 (31). For the case of function $K_{gc}^2(K_{ex2}^2)$ that means the case of function $K_{gc}^2(\vartheta) \rightarrow K_{gc}^2(\vartheta^2/\gamma\eta)$, the set of material parameters $\{\rho, C, e, h, \varepsilon, \mu, \alpha\}$ in paper [14] must be replaced by the set of the corresponding material parameters $\{\rho, C, g, f, \gamma, \eta, \vartheta\}$. For a concrete solid, a complete set of all the material parameters listed and evaluated in table 1 is absent because there are only evaluations of some of small parameters such as ζ, λ, ξ, and β. Some reasons of this horrible absence are discussed in the following section.

4 Discussions

It is a pleasure to deal with a complete set of measured material parameters listed in table 1 for a concrete solid but not with the evaluated values given in the table that can correspond to a majority of corresponding solids. To have measured material parameters $\{\rho, C, e, h, g, f, \varepsilon, \mu, \gamma, \eta, \alpha, \vartheta, \zeta, \lambda, \xi, \beta\}$ listed in table 1 for several concrete solids can be useful for many engineering problems concerning constructions of models of acoustic wave propagation managed by the free surface of a solid, a common interface between two dissimilar solids, a waveguide consisting of thin solid films (plates). For this purpose, it is convenient that the material parameters must be measured and introduced in Nye's tensor notations [15]. This century is positioned as the century of gravity, namely the century for development of gravitational phenomena and their incorporation to electrical and magnetic phenomena. Therefore, gravitational engineers are called to the field of the gravitational engineering. This is like the last century representing the century for the electrical engineering.

In the last century, the piezoelectric effect was recognized as a weak effect that can be neglected when acoustic wave propagation in solids are studied. However, Bleustein [16] and Gulyaev [17] have simultaneously discovered to the end of the 1960s that this weak affect can cause an instability of the shear-horizontal bulk acoustic wave (SH-BAW) leading to the existence of the shear-horizontal surface acoustic wave (SH-SAW) in piezoelectrics. Today, piezoelectrics are important materials in signal processing technologies because various technical devices based on electroacoustic waves (i.e. piezoelectric waves) [18, 19] are incorporated in the modern global communication industry on this planet Earth. The wave properties of the piezoelectric materials are extensively studied during the last half-century. The reader can read books [18]

and [19] on the acoustic wave propagation in crystals. The properties of hundreds of acoustic crystals are combined in book [20] that is convenient because the book provides sets of measured material parameters $\{\rho, C, e, \varepsilon\}$ for piezoelectrics with different crystal symmetries. Acoustic waves can also propagate in piezomagnetic crystals. However there is no book that combined the piezomagnetic material parameters $\{\rho, C, h, \mu\}$ for crystals with different symmetries. Papers [21] and [22] provide the material parameters $\{\rho, C, h, \mu\}$ for some interesting piezomagnetics.

Piezoelectrics together with piezomagnetics are frequently used to model smart piezoelectromagnetic materials also called the magnetoelectroelastics. These materials possess average properties, i.e. have both the piezoelectric and piezomagnetic effects. This results in the existence of a weak magnetoelectric effect in the smart materials. There is no book that combines acoustic properties of the piezoelectromagnetics, for instance, sets of the measured material parameters $\{\rho, C, e, h, \varepsilon, \mu, \alpha\}$. Moreover, only in 2007 Melkumyan [23] has discovered several SH-SAWs that can propagate in the piezoelectromagnetics. This is almost forty years after the discovery of the SH-SAW by Bleustein [16] and Gulyaev [17]. Following work [23], book [24] has discovered additional seven new SH-SAWs. Book [24] has demonstrated that the weak magnetoelectric effect can also cause the acoustic wave propagation, see the fifth new SH-SAW in equation (163) of the book results. And there is only single review paper [25] on the wave propagation in the smart piezoelectromagnetic materials. A study of wave propagation in some strong magnetoelectric materials with the known material parameters $\{\rho, C, e, h, \varepsilon, \mu, \alpha\}$ can be found in paper [26]. When a set of the corresponding material parameters $\{\rho, C, g, f, \gamma, \eta, \vartheta\}$ is used instead of the set of material parameters $\{\rho, C, e, h, \varepsilon, \mu, \alpha\}$, the wave propagation can be also studied. However, nobody has still studied such materials. The acoustic wave propagation transmits energy. Therefore, the gravitational phenomena due to energy transmission must be also taken into account when acoustic wave propagation in studied in the piezoelectromagnetics. As a result, the studied system [1] has already the mechanical, electrical, magnetic, gravitational, and cogravitational subsystems. To disrobe such complicated system, the set of material parameters $\{\rho, C, e, h, g, f, \varepsilon, \mu, \gamma, \eta, \dot{\alpha}, \vartheta, \zeta, \lambda, \xi, \beta\}$ listed in table 1 must be used. At the beginning of the 1990s, Li's research group ([27],[28],[29]) has evaluated the material parameters $\{\gamma, \eta\}$ for a superconducting solid. In 2016, Füzfa [8] has found how

to evaluate some of the exchange material parameters $\{\zeta, \lambda, \xi, \beta\}$ at the earth conditions and found them very weak. In this case, the exchange material parameters $\{\alpha, \vartheta, \zeta, \lambda, \xi, \beta\}$ are very small but it is necessary to demonstrate in further work that they or some of them can cause the acoustic wave propagation and therefore, cannot be neglected in calculations. Moreover, these weak material parameters must be precisely measured and for this purpose, the corresponding measurement technique must be developed.

For new communication era based on some gravitational phenomena, the measured vacuum material parameters $\{\varepsilon_0, \mu_0, \gamma_0, \eta_0, \alpha_0, \vartheta_0, \zeta_0, \lambda_0, \xi_0, \beta_0\}$ must be also known. The vacuum material parameters $\{\varepsilon_0, \mu_0, \gamma_0, \eta_0\}$ are well-known and their values are listed in table 2. However, the rest vacuum parameters $\{\alpha_0, \vartheta_0, \zeta_0, \lambda_0, \xi_0, \beta_0\}$ represent exchange constants that are introduced in this paper and evaluated in table 2. It is expected that their exact values can be obtained in different space experiments. It is well-known that $\alpha^2 < \varepsilon\mu$ ([10],[11]) should occur for any piezoelectromagnetics for a system stability. In general, $\alpha^2 << \varepsilon\mu$ occurs. It is possible to assume that $\alpha_0^2 << \varepsilon_0\mu_0$ must also occur because some exchange between the electrical and magnetic subsystems must exist during the propagation of an electromagnetic wave in a vacuum. Concerning the gravitocogravitic constant ϑ_0, the inequality $\vartheta_0^2 << \gamma_0\eta_0$ must also be assumed for a gravitocogravitic wave (gravitational wave) propagating with the speed of light (11) in a vacuum. It is possible that the exchange parameters $\{\alpha_0, \vartheta_0\}$ can be too negligible to take into account. However, it is possible to write down the following:

$$C_L = \frac{1}{\sqrt{\varepsilon_0\mu_0 - \alpha_0^2}} \sim \frac{1}{\sqrt{\gamma_0\eta_0 - \vartheta_0^2}} \tag{43}$$

The other vacuum exchange parameters $\{\zeta_0, \lambda_0, \xi_0, \beta_0\}$ respectively representing the gravitoelectric, cogravitomagnetic, cogravitoelectric, and gravitomagnetic constants can be also extremely small similar to the parameters $\{\alpha_0, \vartheta_0\}$ discussed above. It is well-known that a massive body can continuously eject electromagnetic and gravitational waves into a vacuum. As a result, the free space (a vacuum) is filled with these types of the fast waves from many bodies. This extremely fast exchange among the four subsystems (electrical, magnetic, gravitational, and cogravitational subsystems) can be evaluated by formulae (16) and (17) for speeds Λ_{01} and Λ_{02}, respectively.

The interaction between the electromagnetic waves and gravitation is well-known for today. The most popular example of this interaction is the effect of captivation of the electromagnetic waves by a black hole located at the center of any galaxy. It is well-known that a black hole can capture an electromagnetic wave by the way that the electromagnetic wave cannot escape. It is assumed that in order to capture any electromagnetic wave propagating with the speed of light in a vacuum, the interaction between this electromagnetic wave and gravitation must be very fast, i.e. significantly faster than any of speed of light. This can mean both the electromagnetic wave and the gravitational wave (both propagating with the speed of light in a vacuum) represent static systems for the interaction processes existing among the electric, magnetic, gravitational, and cogravitational subsystems. This can mean that the exchange signals look like nearly instant (i.e. very high-speed) processes.

It is necessary here to state that the size of our Universe is approximately 100 billion light years, i.e. 100 Gly (Gigalight year). 1 meter is equal to $1.0570008340246 \times 10^{-16}$ light year, or $1.0577248071986 \times 10^{-25}$ Gly. The shape of a Universe is assumed to be a sphere like a bubble. It is possible to estimate that the speeds Λ_{01} and Λ_{02} for a vacuum cannot exceed the limit value of $C_U \sim 10^{27}$ ms^{-1}. It is also expected that the speeds Λ_1 (14) and Λ_2 (15) in a solid can differ from the corresponding vacuum speeds Λ_{01} (16) and Λ_{02} (17). However, a liner size of any solid in our Universe in any direction is too negligible in comparison with the size of our Universe. For instance, the size of our Galaxy called Milky Way with a black hole at the galactic center is only by about 100,000 light years, i.e. six orders smaller than the linear size of our Universe. So, it is expected that a linear size of any solid, solid planet, gas-like planet, star, and even whole Galaxy cannot represent any screen for such (artificially) generated signals travelling with the speeds Λ_{01} and Λ_{02}. Such signal can immediately and simultaneously reach any point inside of our Universe as soon as it is generated at any spot of our Universe. Indeed, it is horrible to communicate with the purely electromagnetic waves (two-potential waves) propagating with speed C_L across the Solar System. For instance, a purely electromagnetic signal can reach planet Mars from Earth in ~ 3 to 20 minutes. Generated four-potential signals propagating with the speeds $\Lambda_{01} >> C_L$ and $\Lambda_{02} >> C_L$ can give our civilization an opportunity of interplanetary, interstellar, intergalactic communications without any significant delays.

5 Conclusion

This report has studied the coefficient of the electromagnetogravitocogravitomechanical coupling (CEMGCMC) K^2_{emgc}. This coefficient is quite complicated because it couples the mechanical, electrical, magnetic, gravitational, and cogravitational subsystems. This theoretical work has demonstrated that the CEMGCMC K^2_{emgc} (3) can be introduced in a convenient form that combines four simplest coupling coefficients (32) plus a complicated exchange term (33). This complicated exchange term consists of several other exchange terms and combines all dependence on the small exchange material parameters α, ϑ, ζ, λ, ξ, and β listed in table 1. It was discussed that the exchange term can significantly decrease the value of the CEMGCMC K^2_{emgc} for small values of α, ϑ, ζ, λ, ξ, and β. These small material parameters for a solid and the possible corresponding parameters α_0, ϑ_0, ζ_0, λ_0, ξ_0, and β_0 for a vacuum were also discussed. It was evaluated and discussed that speeds (16) and (17) for the propagation of four-potential systems can be significantly faster than the speed of light (11) in a vacuum, with which both the two-potential electromagnetic wave and the two-potential gravitocogravitic (gravitational) wave can propagate. Also, this theoretical work can provoke some development of the gravitational engineering research arena for new communication era based on some gravitational phenomena.

References

[1] A.A. Zakharenko, On piezogravitocogravitoelectromagnetic shear-horizontal acoustic waves. Canadian Journal of Pure and Applied Sciences, 10 (3) (2016), 4011-4028; DOI: https://doi.org/10.5281/zenodo.1301184.

[2] A.A. Zakharenko, On new interfacial four potential acoustic SH-wave in dissimilar media pertaining to transversely isotropic class 6 *mm*. Canadian Journal of Pure and Applied Sciences, 11 (3) (2017), 4321-4328; DOI: https://doi.org/10.5281/zenodo.1301215.

[3] A.A. Zakharenko, On existence of new dispersive four-potential SH-waves in 6 *mm* plates for new communication era based on gravitational phenomena. Canadian Journal of Pure and Applied Sciences, 12 (3) (2018), 4585-4591; DOI: http://doi.org/10.5281/zenodo.1471100.

[4] B.P. Abbott, R. Abbott, T.D. Abbott, M.R. Abernathy, F. Acernese, K. Ackley, C. Adams, T. Adams, P. Addesso, R.X. Adhikari *et al.*, Observation of

gravitational waves from a binary black hole merger. Physical Review Letters, 116 (6) (2016), 061102, 16 pages.
[5] A. Einstein, Die Grundlage der allgemeinen Relativitätstheorie. Annalen der Physik, 354 (7) (1916), 769-822. Version of Record online: 14 MAR 2006, DOI: https://doi.org/10.1002/andp.19163540702 .
[6] O. Heaviside, A gravitational and electromagnetic analogy. The Electrician, 31 (Part I) (1893), 281-282 and 359.
[7] O.D. Jefimenko, *Gravitation and Cogravitation. Developing Newton's Theory of Gravitation to its Physical and Mathematical Conclusion*, Electret Scientific Publishing, USA (2006), 367 pages.
[8] A. Füzfa, How current loops and solenoids curve space-time. Physical Review D 93 (2) (2016), 024014.
[9] A.A. Zakharenko, The problem of finding of eigenvectors for 4P-SH-SAW propagation in 6 *mm* media. Canadian Journal of Pure and Applied Sciences, 11 (1) (2017), 4103-4119; DOI: https://doi.org/10.5281/zenodo.1301202 .
[10] Ü. Özgür, Ya. Alivov and H. Morkoç, Microwave ferrites, part 2: Passive components and electrical tuning. Journal of Materials Science: Materials in Electronics, 20 (10) (2009), 911-952.
[11] M. Fiebig, Revival of the magnetoelectric effect. Journal of Physics D: Applied Physics, 38 (8) (2005), R123-R152.
[12] B.M. Yavorsky, A.A. Detlaf and A.K. Lebedev, *The Physics Reference Book for Engineers and Student of the Higher Education*, 8th edition, ONICS Publishers, Moscow (2006), 1054 pages.
[13] J. Kiang and L. Tong, Nonlinear magneto-mechanical finite element analysis of Ni–Mn–Ga single crystals. Smart Materials and Structures, 19 (1) (2010), 015017, 17 pages.
[14] A.A. Zakharenko, On separation of exchange term from the coefficient of the magnetoelectromechanical coupling. Pramana – Journal of Physics, 86 (6) (2016), 1409-1412; DOI: https://doi.org/10.1007/s12043-015-1171-9.
[15] J.N. Nye, *Physical Properties of Crystals. Their Representation by Tensors and Matrices*, Oxford at the Clarendon Press (1989), 385 pages.
[16] J.L. Bleustein, A new surface wave in piezoelectric materials. Applied Physics Letters, 13 (12) (1968), 412-413.
[17] Yu.V. Gulyaev, Electroacoustic surface waves in solids. Soviet Physics Journal of Experimental and Theoretical Physics Letters, 9 (1) (1969), 37-38.

[18] B.A. Auld, *Acoustic Fields and Waves in Solids*, Volumes I and II (set of two volumes), 2nd edition, Krieger Publishing Company (1990), 878 pages.
[19] E. Dieulesaint and D. Royer, *Elastic Waves in Solids: Applications to Signal Processing*, (translated by A. Bastin and M. Motz, Chichester [English]), J. Wiley, New York (1980), 511 pages.
[20] A.A. Blistanov, V.S. Bondarenko, N.V. Perelomova, F.N. Strizhevskaya, V.V. Chkalova and M.P. Shaskol'skaya, *Acoustical Crystals*, in: M.P. Shaskol'skaya (Ed.), Acoustical Crystals, Nauka, Moscow (1982), 632 pages (in Russian).
[21] A.A. Zakharenko, A study of SH-SAW propagation in cubic piezomagnetics for utilization in smart materials. Waves in Random and Complex Media, 22 (4) (2012), 488-504; DOI: https://doi.org/10.1080/17455030.2012.727042.
[22] A.A. Zakharenko, First evidence of surface SH-wave propagation in cubic piezomagnetics. Journal of Electromagnetic Analysis and Applications, 2 (5) (2010), 287-296; DOI: https://doi.org/10.4236/jemaa.2010.25037.
[23] A. Melkumyan, Twelve shear surface waves guided by clamped/free boundaries in magneto-electro-elastic materials. International Journal of Solids and Structures, 44 (10) (2007), 3594-3599.
[24] A.A. Zakharenko, *Propagation of Seven New SH-SAWs in Piezoelectromagnetics of Class 6 mm*, LAP LAMBERT Academic Publishing GmbH & Co. KG, Saarbruecken-Krasnoyarsk (2010), 84 pages, ISBN: 978-3-8433-6403-4; DOI: https://doi.org/10.13140/2.1.4000.8645.
[25] A.A. Zakharenko, Piezoelectromagnetic SH-SAWs: A review. Canadian Journal of Pure and Applied Sciences, 7 (1) (2013), 2227-2240; DOI: https://doi.org/10.5281/zenodo.1300699.
[26] A.A. Zakharenko, Consideration of SH-wave fundamental modes in piezoelectromagnetic plate: Electrically open and magnetically open boundary conditions. Waves in Random and Complex Media, 23 (4) (2013), 373-382; DOI: https://doi.org/10.1080/17455030.2013.834396.
[27] N. Li and D.G. Torr, Effects of a gravitomagnetic field on pure superconductors. Physical Review D, 43 (2) (1991), 457-459.
[28] N. Li and D.G. Torr, Gravitational effects on the magnetic attenuation of superconductors. Physical Review B, 64 (9) (1992), 5489-5495.
[29] D.G. Torr and N. Li, Gravitoelectric-electric coupling via superconductivity. Foundations of Physics Letters, 6 (4) (1993), 371-383.

HADRONIC JOURNAL 41, 371- 384 (2018)
DOI 10.29083/HJ.41.04.2018

THERMODYNAMICS OF THE RELATIVISTIC GIANT ATOM

Emad Eldieb
Cairo, Egypt
eeldieb@yahoo.com

Received February 10, 2019

Abstract

This paper is a continuation for our last research: Physics of the relativistic giant atom (RGA) [1], but focusing here on the thermodynamics of the giant baryon, and putting an answer for the profound question: why matter predominate antimatter in the current universe? Hence, we calculated - from thermodynamics of the giant baryon- the ratio between the baryon and photon number density, where we found complete coincidence with the current measured ratio. Moreover, we searched in a position for the relativistic giant atom among the standard model of cosmology.

Copyright © 2018 by Hadronic Press, Inc., Palm Harbor, FL 34684, USA

Introduction:

Physics of the relativistic giant atom [1] is built on a simple idea: equating the Einstein's equation of the rest energy of a fundamental particle $k\frac{e^2}{r_o} = m_o c^2$ with the Coulomb's equation of the electric energy of a system formed of pure fundamental particles. This equating can physically engulf all the kinetic energies of the system: electric repulsive or quantum exclusive. Hence, the interior of the giant baryon appears in a state of rest energy where it's inside particles condensate and degenerate in the Fermi state with zero absolute temperature. You can rewrite Coulomb's equation to take the Einstein equation form $k\frac{e^2}{r_o}\left(\frac{r_o}{r_c}\frac{p^{\frac{2}{3}}}{(\frac{n}{p})^{\frac{1}{3}}}\right) \equiv m_o c^2$ by equating the factors inside the brackets with the number one. Hence –using this intuit operation- we can get the nontrivial result -which aborts the transitional motion and converts it into rest energy. This is the macroscopic state of the giant baryon. The microscopic states or the physical details -as you can find it in RGA- could be summarized here as follows; since the electric charge quantity e is invariant under Lorentz transformation while the relativistic mass m is variant, so we can –under certain defined condition- expect that the relativistic gravitational potential $u_G(m)$, which is affected by Lorentz transformation more than the electric energy, could be equated with the electric potential $u_e(e)$ and moreover could be equated with the quantum exclusive energy, hence $u_G(m)$ can engulf the other transitional kinetic energies. But the trick here is that the equation $k\frac{e^2}{r_o}\left(\frac{r_o}{r_c}\frac{p^{\frac{2}{3}}}{(\frac{n}{p})^{\frac{1}{3}}}\right) \equiv m_o c^2$ speaks about mass in a rest state m_0 while $u_G(m_{(v)})$ supposes relativistic mass m. Well and good, RGA introduced suspense and adopted a scientific and brave alternate relativistic solution (ARS) in the form of $u_G(n_{(v)}) = G\frac{m_0^2}{R_0}n_{(v)}^2$ instead of $u_G(m_{(v)})$ where n is the number of particles! Hence, ARS carried the scientific seeds of the relativistic baryogenesis. In the second section of RGA we followed up the orbits of the giant atoms and we found suspense: the parameters of the giant atom orbits are completely fit with the current measured parameters of the solar system. This makes us accept the idea that the solar system was, in one of its primordial evolutionary stages, in the form of giant atoms. Moreover this may carry one of the strong evidences which ensure the correctness of the physics of the relativistic giant baryon. This makes us in front of the standard model of cosmology (SMOC).

Here, in this research we search in a position for the relativistic giant baryon among SMOC. Actually as we will see that we can find this position, and moreover my new theory can find solutions for profound cosmologic problems like why matter predominate antimatter in our universe? And like how can we estimate the measured current ratio $\frac{n_b}{n_\gamma} \approx 6 \times 10^{-10}$? The next section is the typical physics of the giant atom but by the language of thermodynamics (kindly, go back to RGA before reading this section).

1- Thermodynamics of the giant baryon:

Let us remember the next given data

a- Baryon number conservation is only approximate; hence there is a bit of baryon number violation and 'pair production and annihilation' asymmetry.

b- Many scientists believe that while matter attracts by its own gravity, antimatter repel [2]. That is baryogenesis problem suggests gravitational asymmetry as an explanation [3][4].

c- The distribution function of hot photon gas is described by $e^{-\frac{\epsilon}{KT}}$, hence at a given constant temperature the function describes spectrum of variant energies.

Now we would go straight forward with the standard model of the hot big bang, but adding only the next case.

1- The case of two photons plus u_g:

At a given constant high absolute temperature $T = \frac{2}{3K} m_o c^2 = 7 \times 10^{12} K$ we can find two photons with extremely small difference of energy $\Delta\epsilon = -u_g$ where $\Delta\epsilon$ equals the positive magnitude of the gravitational potential inside the giant baryon (or the giant electron). So, the collision would be between the two photons a and b with energies equal $\epsilon_a = h\nu_a \equiv m_o c^2 \equiv$ *the rest energy of a neutron* and $\epsilon_b = h\nu_a + u_g \equiv m_o c^2 + u_g$ where u_g denotes the gravitational potential. From RGA, equations 53, 54 and 64 we can write

$$\epsilon_b \equiv m_o c^2 + u_g \equiv m_s c^2 \equiv (m_s c^2 + u_g) - u_g \equiv [m_s(c^2 - \frac{c^2}{c_o})] - u_g$$

It is correct that each of matter and antimatter obeys the same physical laws, but it is remainder that there something discriminates them from each other and can explain how matter predominates antimatter. Here we adopt the opinion that matter attracts by gravity, while antimatter repels. Since that, the baryons can lose a bit of their proper masses to bind by gravity with each other inside a giant baryon. So, in a defined epoch where the absolute temperature (see later) equals $T = \frac{2}{3k} m_o c^2 Kelven$ (k denotes Boltzmann constant) the photon $\epsilon_b \equiv m_s c^2$ cannot behave as bound (giant) antimatter because it cannot acquire extra kinetic energy because the absolute temperature is defined as above. Hence we can conclude that ϵ_a can behave as neutrons while ϵ_b cannot behave as antimatter but it would behave as energetic photon.

Notice; definitely, at temperature (in Kelvin) $= \frac{2}{3k}[m_o c^2 + (m_o c^2 + u_g)] \div 2$, the photon denoted ϵ_b expectedly and most probably, cannot gain extra energy. Since, it repels in gravitational field then its bound state had to gain extra energy to oppose this repulsion. But, the universe, at that moment, and at thermal equilibrium, cannot gain this extra energy. Therefore, ϵ_b fails to exist in a bound state.

2- Conservation of energy of the collision:

Put $Q = -u_g$ and the initial condition of the collision

$$\epsilon_a = m_o c^2 = m_s c^2 - u_g = m_s c^2 + Q$$

$$\epsilon_b \equiv [m_s(c^2 - \frac{c^2}{c_o})] - u_g \equiv [m_s(c^2 - \frac{c^2}{c_o})] + Q$$

As you see the big brackets of the photon ϵ_b describes its energy which is absorbed by the gravity-bound neutron (m_s) of the giant neutron. This kinetic energy is fit to allow the neutrons to degenerate in Compton (Fermi) state with $r = r_c$ This ground state creates de Broglie waves and consequently, the particles vibrate with the corresponding squared mean speed $v^2 = c^2 - \frac{c^2}{c_o}$, hence the particles acquire quantum energy u_c , and in the same time u_g (of ϵ_a) becomes the relativistic gravitational energy $u_G = -u_g c_o = Q c_o$ This positive Q represents and summarizes the equations packet 16 – 22 mentioned in RGA. While the positive Q in the second photon ϵ_b represents the stored gravitational energy inside the sphere such that $(m_o - m_s)c^2 = \Delta m c^2 = Q$.

Conservation of energy in its final condition appears as

$$(m_s c^2 - u_g)_{c_0} + (0 - u_g) = (m_s c^2 c_0 + u_G) + Q$$

Notice that the subscript c_0 means the alternate relativistic action of the Compton state.

Summarizing the above, we can say; only half the number of the hot photons was transformed into baryonic particles (ϵ_a) while the remainder number (ϵ_b) represented the outer brackets or the physical infinite potential barrier described by RGA equation 2 which guided the entire RGA equations (like 18, 22, 23 and 24) towards the output $m_o c^2$ (or accurately $m_s c^2$) which is the kinetic energy of the system per a baryonic particle but in a rest state. Inside the outer brackets there are the inner ones: $m_s(c^2 - \frac{c^2}{c_o})$ which fired out the alternative relativistic action.

Conservation of angular momenta appear as; each two photons $\rightarrow 1 - 1 = 0$ while particles of the giant neutron $\rightarrow \frac{1}{2} - \frac{1}{2} + \frac{1}{2} - \frac{1}{2} + \frac{1}{2} - \frac{1}{2} \ldots\ldots\ldots = 0$

3- As a general solution, to include the ground and the higher states, we can put $\epsilon_b = \epsilon_a + D u_g$ where $1 \leq D \leq 10$

It follows $v^2 = c^2 - \frac{c^2}{c_o} D$

This solution can explain the different orbits of the solar system obeying the order $C_o = c_o D$ (as in RGA equation 87), such that c_o is the replicator factor of the ground state, while C_o is the replicator factor of the general solution.

4- $f(D) = \frac{1}{1+e^{E_i - E_f / KT}} = \frac{1}{1+e^{(mc^2 - E_f)/_0}} = 1$ where $E_f = \frac{5}{3}mc^2$ and $KT \approx 0$

This distribution function of the particles tells us that the particles degenerate into the same ground state. The zero temperature which appears in the above equation is due to that one of the two hot photons is transformed into a baryon, while the second appears as a definition for this baryon in its Fermi (Compton) state.

5- Thermodynamics of the photon could be explained as; the photons $\in_b$ behave as hot photon gas.

Put $V = n_p \frac{4}{3}\pi r_c^3 = 3.7 \times 10^{-25} m^3$

$T = 7 \times 10^{12} \rightarrow kT = 10^{-10} j$

$e^{(h\nu/KT)} = x \rightarrow n_{ph}(\in) = \frac{8\pi V}{c^2}\int_0^\infty \frac{\nu d\nu}{e^{(h\nu/KT)}-1} = 8\pi V(\frac{KT}{hc})^3 \int_0^\infty \frac{x^2 dx}{e^x - 1} = 3 \times 10^{21}\ photon$

which is fit with the number of the baryonic particles inside the giant baryon (RGA equation 52). This means that number density of baryonic particles equals the number density of photons $\rightarrow n_b = n_\gamma$

2- The rational number density $\frac{n_\gamma}{n_b}$:

But the measured $\frac{n_\gamma}{n_b} \approx 1.6 \times 10^9$ [5] which means that the spacing between two neighbor giant baryons is about thousand times the radius of the giant baryon. Let us see how our theory continues with the concluded relation $n_b = n_\gamma$ till we reach to the final correct ratio.

The giant baryon is filled with baryons in the ground state with zero absolute temperature, meaning that the hot photons inside the sphere are exhausted and consumed by the process of the thermal creation of the particles. Because no heat, then no classic transitional motion inside the sphere and no energy around the interior particles except from residual nonrelativistic gravitational potential $u_g = \frac{mc^2}{c_0} = \frac{1.45\times10^{-10}}{1.02\times10^{24}} = 1.4 \times 10^{-34} j$ [1]

Where the replicator factor $c_o \equiv \frac{1}{1-\beta^2} = \frac{1}{1-(\frac{v}{c})^2}$ [1]

This gives the scalar pressure P_g of the total gravitational energy U_g

$$P_g = -n\partial u \div \partial V = \frac{3}{5}GMmn\partial(\frac{4\pi}{3V})^{\frac{1}{3}} \div \partial V = -\frac{nu_g}{3V} = -\frac{2.94\times10^{21}\times1.4\times10^{-34}}{4\pi r^2 r} \qquad (1)$$

Where n is the number of particles inside the giant baryon $= 2.94 \times 10^{21}$[1]

Now, the universe around the giant baryons (spheres) is filled with hot photons having the same number density of the baryon number density inside the spheres (the giant baryons) as mentioned above. The hot photons would give transitional energy to the spheres to collide with the outermost wall of the universe and with each other too. First we assume that the thermal wavelength is smaller than the average distance between each two neighbor spheres (we can prove this later) enough to avoid the quantum effect, and assume that the spheres are rigid enough to deal with the kinetic theory of the ideal gas. For the first moment, we ignore the interior of the spheres and scope on the hot photons which offer the system –at the thermal equilibrium- the average $\bar{v}^2 = \frac{v_1^2+v_2^2+v_3^2....+v_n^2}{N} = 3\frac{kT}{m}$

N denotes the total number of the gas molecules inside the supposed cube.

According to the equipartion energy theory a wall of a cube with 6 walls would be stroked in the time Δt by the number of gas molecules equal Z

$$Z = \frac{1}{6} n\bar{v}\Delta t A \qquad (2)$$

where n denotes the number density $\frac{N}{AL}$.

The total change in momentum $\Delta p = \frac{1}{6} n\bar{v}\Delta t A\ 2m\bar{v}^2$

Finally, the pressure P_s of the gas molecules striking each point of the wall

$$P_s = \frac{1}{3}\frac{N}{AL} m\bar{v}^2 = \frac{2}{3}\frac{N}{AL}\frac{1}{2} m\bar{v}^2 = \frac{2}{3}\frac{E_k}{V} = nkT$$

Where E_k denotes the total kinetic energy

The problem here is that we have not yet concluded, from physics of the relativistic giant atom, the number density of the universe, so I will solve the problem by studding the collisions between the spheres. Using the effective cross section $\sigma = \pi(2r)^2$ while the mean free path $\lambda = \bar{v}\Delta t = \sqrt{2}v\Delta t$

Finally, the familiar equation of the molecules collision takes the form

$$P_s = \frac{kT}{\lambda\sqrt{2}\pi d^2} = \frac{kT}{\lambda\sqrt{2}\pi 4r^2} \text{ [6]} \qquad (3)$$

If we put a bottle of fluid inside a hot container, the molecules inside the bottle would gain speed and get hotter. Also here in our model, the thermal collisions between the entire spheres make the contents inside each sphere hotter and speeder. To put a relation between (1) and (3) let us at first prove the above assumption: the spheres are rigid enough and the collision between the spheres is perfect elastic. Well, to realize that, we need to realize conservation of energy of the collision. This means that we need no energy transfer into the inside of the spheres during collisions. At thermal equilibrium,

there is no heat loss, during collision, neither outside the walls of the universe, nor inside the walls of the sphere.

$$P_s = \frac{k}{\sqrt{2}\pi d^2}\frac{\partial T}{\partial \lambda} = \frac{kT}{\lambda\sqrt{2}\pi d^2} = constant$$

If heat transferred into the interior of the sphere then the collision is not perfect elastic. This is not great problem, because it may be treated by another assumption. The real problem is that the interior of the sphere (go back to RGA) cannot gain extra energy. Moreover, any extra energy would act against the creation of the sphere whose interior particles have defined energy. So, it is necessary that the input energies of a collision equal perfectly the outcome energies. Then, the sphere wall should be rigid.

$P_s \leq P_g$ This is the condition.

Let us study the case: $P_s = P_g$

Now, we go with equation (3) which speaks about the force acting on one wall of the cubic container. The case which we study is that AP_g is the force inside each sphere acting on the entire interior surface area (all the interior faces), while AP_s represents the force exerted on only one exterior direction from the six directions of the space. That is analogue to say that because the entire spheres have the same size so we can consider that each sphere –on the average- is surrounded with 6 spheres. By more accurate sentence we can say we need in this case to use in equation (2) a quantity equal $6Z = N$ to cover all the six directions surrounding each sphere.

$\therefore P_g = 6P_s$ Substitution in (1) and (3) and putting $T = 7 \times 10^{12} \rightarrow kT = 10^{-10}j$

$$\therefore \frac{1.1}{\lambda} = \frac{10^{-3}}{r} \rightarrow \lambda = 1.1 \times 10^3 r \qquad (4)$$

This is the goal. The size between each two neighbor spheres is thousand times the size of the sphere, and consequently the volume of the first should be 1.3×10^9 times the volume of the second. This necessitates the ratio of the number densities $\frac{n_\gamma}{n_b} \approx 1.3 \times 10^9$.

Here we have to put the next notice, the sphere is formed of fundamental particles with distance r_c between each two neighbor particles equal one and half times the Compton wavelength [1].

$r_c = 1.5r \approx 3.135 \times 10^{-16}m$. This is what realizes the ground state of the system inside the sphere. Nothing is below the ground state of the system, and further degeneration is forbidden. So, there is no problem from the case $P_g > p_s$ which is expected later, when the universe gets less hot and more expanding.

3- Outlines for, the standard model, of cosmology and of particle:

We cannot provide a particle speed equals or exceeds that of light. Since that, then if speed described a fundamental particle to be equal that of light, then we describe the rest energy of the rest inertial mass of the particle. If speed of the same particle inside a system is measured or calculated to be equal that of light, then it should be the ultimate kinetic energy gained by the system but in a rest state. The intuit operation mentioned above, which is explained in detail in RGA, can describe the macroscopic picture of such a state. Since we describe ultimate energy then we speak about the suitable epoch of the early hot universe. But rest state means zero energy, zero motion and zero heat. How can we combine ultimate energy with zero energy? The later describes a scalar macroscopic picture, while the second should describe the microscopic physical details.

In the early universe –as the Standard Model of cosmology says- gravity had frozen out prior the other fundamental forces. On the level of the standard Model of particles we can supposes that gravity should appear in both the macro and microscopic picture while the other forces may not appear in the level of the macroscopic picture (as you see in our model, the final macroscopic picture is zero energy except u_g). Hence a system of fundamental particles in a bound state must appear gravity. So gravity u_g should be counted in the ultimate energy $\equiv m_0c^2$ of the system. This means that the microscopic physical details of the ultimate energy of the system should speak only about the quantity $m_0c^2 + u_g$. This guarantees that the ultimate (rest) energy of the system of the bound particles never exceed the quantity m_0c^2

We can summarize the entire of the above discussion as: the kinetic energy which the hot early universe can offer for a system of bound particles should not exceed $m_0c^2 + u_g$

This kinetic energy in a system of gravity-bound particles appears finally (after adding u_g) in the rest state $(m_0c^2 + u_g) - u_g \equiv m_0c^2$

This is the ultimate energy gained by our bound system which is mathematically expressed by the last mentioned intuit operation.

As in the Standard Model of cosmology, when the temperature of the universe was about $T = \frac{2}{3K}m_oc^2 = 7 \times 10^{12}K$ creation of the neutrons took place. According to RGA, half of this heat was consumed in the thermal baryogenesis to leave zero heat inside the giant baryon. The space around the giant baryons was full with hot photons with number density equal that of the baryons inside the giant baryons. The thermal pressure of the universe as we explained above modified the ratio to be instead, $\frac{n_\gamma}{n_b} \approx 10^9$. Thermodynamics of the relativistic giant atom can go straight forward with SMOC as next. Through β decay, in the thermal equilibrium, the neutron–proton ratio $\frac{n}{p} = e^{-u/kT}$, $u = (m_n - m_p)c^2 = 1.293MeV$

The conversion reactions become slow compared to the age of the universe at $t{\sim}3$ seconds, $kT{\sim}0.7MeV$

Since the interaction rate is dropping quickly as the density and temperature of the universe decline, there are no subsequent conversions.

The neutron-to-proton ratio "freezes in" at $e^{-1.283/0.7} = \frac{1}{6}$

Charge conservation needs equal proton electron ratio.

4- False problems face the relativistic baryogenesis:

The first problem is that it violates baryon number conservation. Actually the relativistic creation of particles in the net and final result is not real. As RGA stated (you are advised to go back to the original paper), the relativistic number served the current universe to fix the orbiting system in its orbits, but really it doesn't supply the current universe with any baryon. That is because throughout the neutron decay process, the size of the giant baryon was increasing which led to decrease the intrinsic oscillatory motion of the particles inside the giant baryon. So, we cannot count in the current universe relativistic number, and we return again to the thermal number only.

The second false problem in RGA is the concerning the mathematics of equations 21, 22 and 23. That is in the left side of each equation we see relativistic number, but in the right sides we not see such relativistic number. That is because the right side of each equation have reached the ultimate energy, and we should obey the intuit operation which refuses excess quantity of energy.

The third one is that, the left side of each of these equations does not go straight forward with the conventional familiar gravitational energy. Actually neither the left side describe gravitational nor does the right side describe electric potential. Our uses of these two potentials were actually metaphorical. We began the packet of the equations from the equation which describes the rest mass of a fundamental particle, then we introduced on the same equation intuit operation to offer the bound particles ultimate kinetic energy equivalent to m_0c^2 but in rest state. Therefore we have to do mathematic simplification to equate each side with the quantity m_0c^2

The forth false and serious problem arises from misunderstanding or may be momentary forgetting the cardinal idea which the entire work is built on. So, let us stress on $\because k\frac{e^2}{r_o} = m_0c^2$ Einstein's equation describing rest energy of the fundamental particle. And, $\because k\frac{e^2}{r_o}\left(\frac{r_o}{r_c}\frac{p^{\frac{2}{3}}}{(\frac{n}{p})^{\frac{1}{3}}}\right) = E_{(p,r)}$ Coulomb`s equation (modified but the same form) describing the electric potential inside a spherical shape with radius $r_c n^{)\frac{1}{3}}$ composed of number of protons (or electrons) p, distributed homogeneously among much more number of neutrons n,

And if we chose $\left(\frac{r_o}{r_c}\frac{p^{\frac{2}{3}}}{(\frac{n}{p})^{\frac{1}{3}}}\right) = 1$

$\therefore E_{(p,r)} \equiv m_o c^2$. This is intuitive operation, but carries the serious nontrivial result: all the positive energies; electric kinetic and quantum exclusive inside the block $k\frac{e^2}{r_o}\left(\frac{r_o}{r_c}\frac{p^{\frac{2}{3}}}{(\frac{n}{p})^{\frac{1}{3}}}\right)$ became in a rest state. (the system itself is zero energy).

$$v^2 = c^2 = c^2\left(1-\frac{1}{\gamma^2}\right)+\frac{c^2}{\gamma^2} = \{c^2\left(1-\frac{1}{c_o}\right)\}+\frac{c^2}{c_o} = \{c^2\left(1+\frac{u_g}{m_o c^2}\right)\}-\frac{u_g}{m_o} \quad [1]$$

This is a second form for the same block describing the final rest state of the particles inside the sphere. The contents inside the outer brackets of each side describe real oscillatory motion with estimated high relativistic speed $v^2, = c^2(1-10^{-24})\ {}^{m}/_{s}$ but each entire side of the above equalities represents the macroscopic rest state [1].

The speed of the mass center of the sphere (block) relative to the interior contents is really zero, so it can move relative to other block. This describes the packet of equations of the orbit of the giant atom (the second part of RGA). But the interior contents themselves cannot gain extra energy over its own ultimate energy, or by other words, the intrinsic squared relative speed of the oscillatory particle motion -inside each sphere- is ultimate and constant. This is described by the equations packet of the giant baryon (the first part of RGA).

Well, equation 84 (RGA) defined the radius of the orbit of the giant atom such that the center of the giant charge is the one which orbits as defined by equation 76 (RGA). Equation 76 (RGA) put a condition should be fulfilled for the sphere to orbit another one. If the condition was fulfilled then the center of the mass of the sphere is the one which orbits and is the one which gains the motion energy, while the particles inside the giant charge do not gain excess energy over its intrinsic own energy. Since the own intrinsic energy of the single particles inside the giant charge is ultimate such that it cannot gain any excess energy, and since the orbital motion do not supply these singled particles any quantity of energy then, no problem arises from this orbital motion. The problem arises from the transitional motion due to repulsive electric force between the identical charges. That is because the distances between the giant charges as defined by $\lambda = 10^3 r$ is comparatively so small that the giant charges do not obey the condition mentioned in equation 76 (RGA), hence, the center of the mass of the identical giant charges is not the one which moves but the singled charges are the ones which move. Each single charge is described –inside the giant charge- by ultimate intrinsic energy and cannot accept further energy. Hence, the positive energy (due to repulsion) between the identical giant charges is forbidden.

After all, this paper with its mother previous one does not aim to put a new theory for the early universe. Its main great aim is that it tries –under defined conditions may not be

fulfilled up till now except in the early universe- to rearrange the fundamental laws of physics and then begins with the simplest intuit operation: $A \times 1 = A$. From this one we can coalesce and combine fundamental particles to form the giant baryons. These can form giant atoms. When we followed up the parameters of these giant ones we found complete coincidence with the current parameters of the orbits of the solar system. Later on, -after departure of the charges from interior of the giant charged spheres and by collection and attraction of the spheres with each other, the Newtonian`s laws received the file leaving behind the same parameters as an evidence for that the solar system in one of its primordial evolutionary stages was in the form of giant atoms [1].

This represents the main difference with the common theory which considers the solar system had originated from giant molecular cloud [7]. We believe that our theory is more persuaded because it began from the simplest intuit operation. Anyway, you can see our theory from a side far from the discussion about the origin of the solar system: when we began from the simplest intuit operation we succeeded to create a system similar to the solar system! Moreover, we succeeded to calculate -with high accuracy- the rational number density $\frac{n_b}{n_\gamma}$.

As a philosophic insight for the entire above, I can say that if we want to rearrange the physical fundamental laws of the universe from the oldest in action to the recent, or from the most respective downwards, then we have to begin with $c\ is\ ultimate \rightarrow v < c$ and then, $k\frac{e^2}{r_o} = m_o c^2$

5- Can we create a giant baryon?

This research is not experimental, but I believe that mathematics may precede experiment. Possibility of existence the giant baryon may have evidences or at least the next presumptions. First, creation of the giant baryon needs temperature $7 \times 10^{12} k$, while the highest temperature created by LHC is $4 \times 10^{12} k$. This gives us hope and expectancy to get in the future the critical temperature. I believe that my previous paper (RGA) have prepared theoretical long study. The study succeeded to create a physical model for the relativistic giant atom. We found complete coincidence between the parameters of these models and the orbits of the solar system. I may consider this coincidence a realization of the model in the lab of the sky. Second, since this threshold temperature was present in the hadron epoch, so in this present paper I studied the thermodynamics of the giant baryon, where I found that the parameters of the relativistic giant baryon can easily solve a profound cosmologic problem which is known as the ratio $\frac{n_\gamma}{n_b}$

This high temperature is not the only condition required for creation a universe or a colony of giant baryons. We need also a second condition (the subject of this article) represented in equating the pressure inside the giant baryon which presses inwards the sphere, with the pressure of the hot universe pressing the contents of the sphere outwards. This is realized by equation 4 which means that the relative number density $\frac{n_b}{n_\gamma} \approx 6 \times 10^{-10}$.

Fortunately, the temperature we need to create giant baryon is only

$$T = \frac{2}{3k} m_o c^2 - \frac{1}{10^{24} \times 1.021} K\,!$$

I suggest that creation of one giant baryon (the subject of our previous paper: RGB) needs a defined number n, of the fundamental particles with

$$r_c \approx \sqrt{3.135 \times 10^{-16} + \frac{1}{1.021 \times 10^{24}}\, m}$$

This in-between distance means high number density giving quantum squared speed defined by $v^2 = c^2\left(1 - \frac{1}{10^{24} \times 1.021}\right)$. Physics of the relativistic giant atom defined the magic equality:

$$\frac{c^2}{10^{24} \times 1.021} = \frac{2u_g}{m} = v_g^2$$

This occurs by choosing n to realize the gravitational kinetic energy u_g of each particle.

Adding the two squared speeds we get $v_t^2 = c^2\left(1 - \frac{1}{10^{24} \times 1.021}\right) + \frac{c^2}{10^{24} \times 1.021} = c^2$

From this magic equality we get the serious result: the entire energy of the system per a particle is represented by the rest energy $u \equiv m_0 c^2$

We also get an alternate relativistic solution in the form of $n_{(v)}$. The details you can find in RGA, but this simplified method shows how we can realize the condition required for the intuit operation which aborts the entire kinetic energies of the system.

Practically, I can suggest using the general solution which enables us to degenerate the defined number n of subatomic particles under the critical temperature:

$$T = \frac{2}{3k} m_o c^2 - \frac{D}{10^{24} \times 1.021} K = \frac{2}{3K} m_o c^2 - \frac{10}{10^{24} \times 1.021} K$$

Conclusion

Our last published paper: physics of the relativistic giant atom have succeeded to explain –with high accuracy- many astronomic parameters for the solar system. Here, in this present paper we can rewrite the same physics but by the language of thermodynamics. This enabled us to calculate -with respective accuracy- the current ratio $\frac{n_b}{n_\gamma}$

References

1- Eldieb Emad, Physics of the relativistic giant atom. International journal of theoretical and mathematical physics 2017; 7(4): 68-89

2 Kowitp,M. (1996), 'Gravitational repulsion and Dirac antimatter' International journal of theoretical physics, 35(3): 605 – 631

3 Hajdukovic,D. Do we live in the universe successively dominated by matter and antimatter? Astrophysics, Space sci. 334, 219 – 223 (2012)

4 Benoit-levy, A. & Chardin, G. Introducing the Dirac – Milne universe. Astron. Astrophysics, 537, A78 (2012)

5 D. N. Spergel et al, arXiv –astro-ph/0603449

6 Mean free path, molecular collision. Hyperphysics-astr,gsu,edu. Retrieved 2011-11-08

7 Audrey Bouvier, Meenakshi wadhawa (2010). The age of the slar system redefined by the oldest pb – pb age of a meteoritic inclusion. Nature Geoscience.3: 637 - 641

INDEX
HADRONIC JOUNAL, VOLUME 41, 2018

PROBABILISTIC MECHANICS: THE HIDDEN VARIABLE, 1
Richard Lawrence Norman
Editor in Chief, Mind Magazine Journal of Unconscious Psychology
Scientific Advisor Thunder Energies Corporation
J. Dunning-Davies
Department of Mathematics and Physics (Retd.)
University of Hull, England;
Institute for Basic Research, Palm Harbor, FL, USA
UNIVERSE (PARTICLES) AND ANTI-UNIVERSE (ANTIPARTICLES) AS WELL AS VACUUM ENERGY DENSITY OR COSMOLOGICAL "CONSTANT" INCLUDING QUANTUM GRAVITY, 95
H. Strusny
Hohenschoenhauser Str. 1, 10369 Berlin, Germany
THE NEW THEORY OF GRAVITY BASED ON MACH'S PRINCIPLE AND QUANTUM MECHANICS, 199
Vasily Yanchilin
Newspaper of the Scientific Community "Poisk"
Vavilova, 30/6, 119991, Moscow, Russia
ACCURATE MASS FORMULAS AND PREDICTION OF MASSES ON HEAVY FLAVOR HADRONS, 221
Yi-Fang Chang
Department of Physics, Yunnan University, Kunming, 650091, China
INSUFFICIENCES OF GENERAL RELATIVITY, 223
Chun-Xuan Jiang
China Aerospace Science and Technology Corporation
P.O. Box 142-206, Beijing 100854, P.R. China
CONSEQUENCES OF THE EXISTENCE OF AN AETHER, 247
Rich Norman
Scientific Advisor Thunder Energies Corporation
1444 Rainville Rd., Tarpon Springs, FL 34689
Editor in Chief, Mind Magazine; Journal of Unconscious Psychology
J. Dunning-Davies
Department of Mathematics and Physics (Ret.d)
University of Hull, Cottingham Road, England
RESOLVING PROBLEMATIC THERMODYNAMICS, 259
Kent W. Mayhew
68 Pineglen, Ottowa, Canada

ALTERNATE WORLD VIEW, 273
Tepper L. Gill
EECE Howard University, Washington, DC 20059
COMPUTATIONAL ATOMIC PHYSICS FOR THE FUTURE: MODULAR REALIZATION OF ATOMIC CONSTITUTION AND PERIODIC SYSTEM, 305
Erik Trell
Faculty of Health Sciences, Linköping University
581 83 Linköping, Sweden
MASS PREDICTIONS AND LIFETIME FORMULAS OF HEAVY FLAVOR HADRONS, AND SIMPLIFY OF SUPERSYMMETRY, 335
Yi-Fang Chang
Department of Physics, Yunnan University
Kunming, 650091, China
ON SEPARATION OF EXCHANGE TERMS FOR FOUR-POTENTIAL ACOUSTIC SH-WAVE CASE WITH DEPENDENCE ON GRAVITATIONAL PARAMETERS, 349
Aleksey Anatolievich Zakharenko
International Institute of Zakharenko Waves (IIZWs)
660014, ul. Chaikovskogo, 20-304, Krasnoyarsk, Russia
THERMODYNAMICS OF THE RELATIVISTIC GIANT ATOM, 371
Emad Eldieb
Cairo, Egypt

INDEX VOL 41, 2018.....385